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The Parsing and Interpretation of Comparatives: More than Meets the Eye

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THE PARSING AND INTERPRETATION OF COMPARATIVES: MORE THAN MEETS THE EYE

A Dissertation Presented

by

MARGARET ANN GRANT

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THE PARSING AND INTERPRETATION OF COMPARATIVES: MORE THAN MEETS THE EYE

A Dissertation Presented

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MARGARET ANN GRANT

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This dissertation is dedicated to my parents, Martha and Curry Grant.

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ABSTRACT

THE PARSING AND INTERPRETATION OF COMPARATIVES: MORE THAN MEETS THE EYE

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This dissertation examines comparative constructions, both in terms of their representation in syntax and semantics and in terms of the way these representations are built and interpreted incrementally during sentence processing. While there has been extensive investigation of comparatives in the syntax and semantics literature (see Bresnan, 1973; von Stechow, 1984; Heim, 1985; Kennedy, 1999, among others), there has been little work on how comparatives are processed (although see Fults and Phillips, 2004; Wellwood et al., 2009 for work on so-called *comparative illusions*). In the first half of the dissertation, I address issues that are primarily syntactic in nature; in the second half, I address issues that are primarily at the semantic and pragmatic levels. In Chapter 2, I examine the basic syntax of English comparatives and readers' expectations for the structure of comparatives during parsing. I present evidence from eye movements during reading to argue that a curious pattern of acceptability in comparatives (observed by Osborne, 2009) arises from processing factors rather than the grammar. Chapter 3 provides evidence from self-paced reading that, in contrast to what has been shown for other more widely studied structures, in comparative clauses subject gaps are more difficult to process than object gaps. Some potential accounts for this asymmetry between comparatives and other structures are discussed, and in Chapter 4, I argue

for a grammar-based account of the subject gap penalty. Chapters 5 and 6 investigate questions in the semantics/pragmatics and semantic processing of comparatives. In Chapter 5, I introduce a previously unstudied type of comparative, which I call *subset comparatives*, and investigate their appropriate formal representation. In addition to their theoretical interest, subset comparatives can provide insight into comprehenders' expectations regarding the relationship between the two sets of entities involved in comparatives. Evidence from eye movement studies suggests that readers have an initial preference for contrast, or disjointness, between sets in comparatives. Chapter 6 investigates issues in the comparison of pluralities during on-line sentence processing, again as studied through eye movements during reading. This chapter provides evidence that, when comparing sets, comparisons that involve degrees along an adjectival scale involve complexity beyond that involved in comparing sets in terms of their cardinalities. The results of my experimental studies on comparatives are related to broader issues in linguistics and psycholinguistics, such as the sources of well-formedness (or ill-formedness) in language, the representation of linguistically described sets in language processing, and the interaction between levels of information (syntactic, semantic, and conceptual/world knowledge) in comprehension.

TABLE OF CONTENTS

Page

ACKNOWLEDGMENTS . . . . **v**

ABSTRACT . . . . **vii**

LIST OF TABLES . . . . **xiv**

LIST OF FIGURES . . . . **xv**

CHAPTER

1. INTRODUCTION **1**

1.1 Linguistic-theoretical background on comparatives 2

1.1.1 The empirical range of comparatives in English 2

1.1.1.1 The anatomy of a comparative 2

1.1.2 The syntactic and semantic architecture of comparatives 3

1.1.2.1 The ‘standard’ approach 4
1.1.2.2 The measure phrase analysis of gradable adjectives 6
1.1.2.3 Late merger of Degree Clauses 7
1.1.2.4 *Than*-phrases and clauses 8
1.1.2.5 Comparative Deletion and Subdeletion 9

1.1.3 Cross-linguistic variation in comparatives 12

1.2 Psycholinguistic background 13

1.2.1 Previous relevant psycholinguistic work 15

1.2.1.1 Processing comparative illusions 16
1.2.1.2 Parallelism in processing comparatives 18
1.2.1.3 Processing adjectives 19
1.2.1.4 The use of adjectival meaning with respect to a ‘visual world’ 22

1.3 Comparison studies in cognitive psychology 24
1.4 The role of implicit prosody in reading 26

1.5 Outline of the Dissertation 29

1.5.1 Chapter 2: Garden paths in comparatives 29
1.5.2 Chapter 3: Gaps in comparative clauses 29
1.5.3 Chapter 4: Island violations and the subject gap penalty 30
1.5.4 Chapter 5: Subset comparatives 30
1.5.5 Chapter 6: Cardinalities and Degrees 30

1.6 Data sources and data analysis 30

2. GARDEN PATHS IN COMPARATIVES 32

2.1 Introduction 32
2.2 Unparsable Grammaticality 33
2.3 Why the pattern is a puzzle for current theories 37
2.4 More (than) as a two-place determiner 38
2.5 Garden Paths in Comparatives 40
2.6 Experiment 1 42

2.6.1 Methods 43
2.6.2 Results 44
2.6.3 Discussion 48

2.7 Reanalysis and reanalysis failure 49

2.7.1 Difficulty of Reanalysis 50

2.7.1.1 **Structural Factors** 50
2.7.1.2 Evidence signaling reanalysis 53

2.7.2 Reanalysis failure and Grammaticality 54
2.7.3 Probabilistic theories 56

2.8 Previous accounts 57

2.8.1 The Functional Equivalence Account 57
2.8.2 Subcomparatives in base position 61
2.8.3 Gaps in comparative clauses 64

2.9 Concluding Remarks 66

3. GAPS IN COMPARATIVE CLAUSES 68

3.1 Introduction 68
3.2 Theories of relative clause processing 71

3.2.1 Storage, integration and interference in processing relative clauses 71
3.2.2 Structural Distance 73
3.2.3 Perspective maintenance 74
3.2.4 Semantic indeterminacy, frequency and surprisal 75

3.2.5 Discourse and relative clauses 76
3.2.6 The Active Filler Hypothesis 77
3.2.7 Predictions for Comparative Clauses 78

3.3 Experimental Data 80

3.3.1 Experiment 2 80

3.3.1.1 Methods and Procedure 81
3.3.1.2 Results 82
3.3.1.3 Discussion 86

3.3.2 Experiment 3 87

3.3.2.1 Method 87
3.3.2.2 Results 88
3.3.2.3 Discussion 90

3.4 Summary of the empirical pattern and the remaining problem 90

3.4.1 Summary of Experiments 2 and 3 90
3.4.2 Relative clauses vs. comparative clauses 91
3.4.3 Focus resolution and comparative clauses 93

3.5 Subject comparative clauses in object position 95

3.5.1 Pilot Experiment 4 96

3.6 A Processing Account 97

3.6.1 A processing bottleneck 97
3.6.2 Experiment 5 99

3.6.2.1 Materials and Procedure 99

3.6.3 Results 100

3.6.3.1 Discussion 102

3.7 Accounting for the Subject-Gap Penalty 103

4. ISLAND VIOLATIONS AND THE SUBJECT GAP PENALTY 104

4.1 Syntactic properties of relative and comparative clauses 105

4.1.1 Raising and Matching 105
4.1.2 Comparative subordination vs. coordination 108

4.2 Movement in comparative clauses 110

4.2.1 Subject islands in Slavic phrasal comparatives 117

4.2.2 Is a subject island account viable? . . . 122
4.2.3 Order of information in comparatives . . . 123

4.3 Subject and Object Gaps in Japanese . . . 124

4.3.1 Comparatives and Relative Clauses in Japanese . . . 125

4.3.1.1 Relative Clauses . . . 125
4.3.1.2 Comparatives . . . 125

4.3.2 Previous results on the processing of relative clauses in Japanese and other languages with pre-nominal RCs . . . 126
4.3.3 Experiment 6 . . . 132

4.3.3.1 Method . . . 132
4.3.3.2 Results . . . 134
4.3.3.3 Discussion . . . 135

4.4 General Discussion . . . 140

5. SUBSET COMPARATIVES . . . 143

5.1 Introduction . . . 143
5.2 Subset Comparatives . . . 145
5.3 Subset comparative syntax . . . 147
5.4 Subset comparative meaning . . . 152
5.5 Subset comparative processing . . . 154

5.5.1 Experiment 7 . . . 156

5.5.1.1 Method . . . 156
5.5.1.2 Results . . . 158
5.5.1.3 Discussion . . . 163

5.6 The Role of *Just* in Subset Comparatives . . . 166
5.7 The Role of *Just* in Processing Subset Comparatives . . . 173

5.7.1 Experiment 8 . . . 173

5.7.1.1 Methods . . . 174
5.7.1.2 Results . . . 175
5.7.1.3 Discussion . . . 178

5.8 Subset comparative clauses . . . 181

5.8.1 Pilot Experiment 9 . . . 183
5.8.2 Implications for a theory of comparative interpretation . . . 185

5.9 Subset comparatives as true subsets . . . 187
5.10 Conclusions . . . 193

6. COMPARING SETS IN ON-LINE SENTENCE PROCESSING **196**

6.1 Introduction 196
6.2 The representation of sets 200

6.2.1 Representing and modifying sets 200
6.2.2 Representing and accessing members of sets 201

6.3 Visually verifying comparatives and comparative quantifier statements 207

6.3.1 Semantic Types and complexity 212

6.4 Cardinalities and degrees in language 214

6.4.1 The meaning of *many* 215
6.4.2 The distribution of cardinality and degree comparatives 216

6.5 The Degree Complexity Hypothesis 222
6.6 Experiment 10 230

6.6.1 Design 230
6.6.2 Method 232
6.6.3 Results 232
6.6.4 Discussion 239

6.6.4.1 Priming of degree comparison 239
6.6.4.2 Attributive and predicative comparatives 241

6.7 Conclusions and Implications for Future Research 243

7. CONCLUSIONS **246**

7.1 Conclusions for the grammar of comparatives 246
7.2 Conclusions for the relationship between grammar and parsing 249
7.3 Filler-gap processing in comparatives 250
7.4 Conclusions for the representation of semantic types 252
7.5 Conclusions for semantic processing 253
7.6 What type of information takes primacy in processing? 253
7.7 Conclusions 256

APPENDICES

A. APPENDIX OF EXPERIMENTAL MATERIALS **257**
B. VERB BIASES, EXPERIMENT 5 . . . . . . **294**
C. APPENDIX OF MODEL PARAMETERS **295**

BIBLIOGRAPHY **320**

LIST OF TABLES

Table **Page**

2.1 Means for eye-movement measures, Experiment 1 47

2.2 Mean accuracy on comprehension questions. 48

3.1 Mean reading times, Experiment 2. 84

3.2 Mean reading times for the summed than-phrase and main VP regions. 84

3.3 Comprehension question accuracy rates (% correct) by condition, Experiment 2. 86

3.4 Mean reading times per condition per region, Experiment 3. 90

3.5 Mean naturalness ratings, Experiment 3. 90

3.6 Mean ratings per condition, Experiment 4. 96

3.7 Mean verb biases, Experiment 5 (based on norms from Gahl et al., 2004b). 100

3.8 Mean comprehension accuracy, Experiment 5. 102

5.1 Means for eye-movement measures, Experiment 7 159

5.2 Means for eye-movement measures, Experiment 8 175

5.3 Mean ratings and paraphrase responses, Experiment 9. 184

6.1 Means for eye-movement measures, Experiment 10 234

6.2 Mean Total Time, Experiment 10 Region 5, by connective. 239

LIST OF FIGURES

Figure **Page**

2.1 Regressions Out and Regressions In by region. Bars indicate standard errors of the mean. 47

3.1 Mean reading times by region, Experiment 2. 83

3.2 Mean reading times, Experiment 2 for arithmetic question (left) and no arithmetic question (right) conditions. 85

3.3 Mean reading times by region, Experiment 3. 89

3.4 Schematic of the integration of words into the structure in object and subject gap comparative clauses. 98

3.5 Mean reading times by region, Experiment 5 101

4.1 Mean reading times by region, Experiment 6. 136

4.2 Mean reading times by region, Experiment 6 control items. 137

5.1 Two possible scenarios in which (230) is true. The left group shows six lawyers (represented by ‘L’) and four parents (represented by ‘P’) with no overlap. The right panel shows a scenario in which there are eleven lawyers and nine parents, but five of the individuals are both lawyers and parents (‘LP’). 145

5.2 First Pass Times by region, Experiment 7 161

5.3 First Pass Times on Region 6, split into early and late portions of the experiment. 162

5.4 Go-Past Times by region, Experiment 7 163

5.5 Regressions Out by region, Experiment 7 164

5.6 Regressions Out split into early and late portions of the experimental trials, Experiment 7. 165

5.7 Mean Go-Past Times by region, Experiment 8. 177

5.8 Go-Past Times for the first and second halves of experimental trials, Experiment 8. 178

5.9 Mean Go-Past Times by region, Experiment 8 179

6.1 Grey and black boxes: 1. 225

6.2 Grey and black boxes: 2. 226

6.3 Grey and black boxes: 3. 226

6.4 Grey and black boxes: 4. 226

6.5 Go-past times for all regions, Experiment 10. 236

6.6 Total fixation times for all regions, Experiment 10. 237

6.7 Go-Past and Total Times for the critical region (Region 5), Experiment 10. Bars indicate standard errors. 238

CHAPTER 1

INTRODUCTION

In this dissertation, I investigate the representations of comparative constructions, and how these representations are formed during on-line sentence processing. The syntactic and semantic complexity of comparatives make them a fruitful empirical domain for investigating many important questions in linguistics and psycholinguistics. The goals of the dissertation are twofold: to use the processing of comparatives to give insight into the representations of comparatives, and to gain insight into the process of comprehending syntactically and semantically complex structures through examination of the processing of comparatives. While these two goals might be classified as (experimental) linguistic and psycholinguistic, respectively, I believe that pursuing the two jointly can be informative beyond what is possible from separate lines of inquiry. Evidence from sentence processing can be used to inform formal models of linguistic representations, and detailed theories of linguistic structure and meaning can, and must, inform hypotheses regarding the processing of linguistic structures.

Within the processing of comparatives, I will address both syntax-focused and semantics-focused questions. The issues I address in the syntactic parsing of comparatives include the division of labour between the grammar and the parser in terms of predicting patterns of acceptability and default expectations that readers hold regarding the structure of comparatives (Chapter 2), as well as the processing of gaps left by the process of Comparative Deletion (Chapters 3-4), defined below in Section 1.1.1. I also address questions of how readers compute the meanings of comparatives during on-line processing, including assumed relationships between sets under comparison, and the computational complexity of comparing plural sets along a single scale.

In this introductory chapter, I will lay out the assumptions that will carry throughout the rest of the dissertation, and a summary of some of the relevant literature that has been carried out on these topics. Literature that is relevant to particular chapters of the dissertation is discussed in those chapters; here I will present a brief sketch of what has been found about the structure, meaning and processing of comparatives and gradable adjectives. The assumptions that I will present include a basic model of the representation of comparatives (Section 1.1.2), as well as a general framework for the incremental processing of linguistic input (Section 1.2). In Section 1.3, I will summarize some of the literature on comparison outside of linguistics, as the way that humans carry out cognitive operations like comparison can be expected to have an effect on how these operations are encoded and processed in language. Section 1.5 will provide a roadmap of the theoretical questions to be addressed in each of the chapters of the dissertation, and 1.6 will introduce the methodology and sources of empirical data that will be considered in later chapters.

1.1 Linguistic-theoretical background on comparatives

1.1.1 The empirical range of comparatives in English

There has been extensive study of English comparatives in the linguistics literature, likely because comparatives exhibit many of the phenomena that a theory of grammar must account for. Bresnan (1973) calls comparative clause constructions “a fecund source of ambiguities and puzzles." In this section, I will present some of the varieties of comparative construction that have been important in the discussion of comparatives in English (and languages with similar comparatives). The empirical range of comparative constructions, even just those in English, is too large to be addressed in one dissertation. I will be primarily concerned with comparisons of cardinality or quantity, although Chapter 6 will depart from this. I will also be primarily testing comparatives in subject position, although Chapters 3 and 6 include investigations of non-subject position comparatives.

1.1.1.1 The anatomy of a comparative

The literature on comparatives uses a variety of terms to describe different pieces of the construction. Some of these terms are based in the syntactic structure of comparatives, and some are based in the meaning of comparatives. Some are meant to describe a part of a comparative construction in a particular language, while others are more typologically general. In English, comparatives are characterized by the presence of words like *more*, *less*, or adjectives marked by *-er*. Typically *-er* is referred to as the *comparative morpheme*. In the typology of comparatives, many languages lack overt comparative morphemes (Stassen, 1985; Beck et al., 2004; Kennedy, 2007a, ,among others).

The comparative morpheme attaches to adjectives (e.g., *taller*) or is realized as *more* in non-synthetic forms (*more intelligent*). These adjectives modify (in a non-technical sense) the *associate of comparison*. In (397a), the adjective appears in *predicative* position, while in (396a), the adjective directly modifies the associate of comparison in *attributive* position.

(1)

Paige	is	taller	than	Colin is ~~*d-tall*~~
ASSOCIATE		ADJ+*er*	STANDARD MARKER	STANDARD

(2)

Paige	has	a	shinier	sticker	than	Colin has ~~*a d-shiny sticker*~~
			ADJ+*er*	ASSOCIATE	STANDARD-MARKER	STANDARD

Comparatives in English also generally include the word *than*, which is the English *standard marker* that marks the *standard of comparison* to which the associate is being compared. In the dissertation, I will sometimes discuss the standard marker and standard of comparison in more syntactic terms, referring to them as a *than*-phrase or clause, or comparative clause.

Last, there is the *property* on which the associate and standard are being compared. This property might be *having height* as in (397a), or the property of having attended the party in (3). In most of the sentences used in the dissertation like in (3), the property of comparison corresponds to the VP of the matrix clause.

(3) More people than I invited attended the party.

Terms like associate and standard, and property of comparison are important because they label parts of the comparative that are present across languages. Terms like *comparative morpheme* only apply to languages that have such a morpheme, and terms like *than*-clause are applicable only in English. In the upcoming chapters, I will use the terminology that makes sense for the scope of discussion, keeping the typological facts in mind.

1.1.2 The syntactic and semantic architecture of comparatives

In this section, I will present a hypothesis for the underlying structure of comparatives. In subsequent chapters, I will discuss aspects of the syntax and semantics of comparatives in greater detail according to the chapter's content. Before introducing some proposed theories of the syntax and semantics of comparatives, a few basic assumptions are required. Here I will assume that there is a semantic type *degree* (marked by *d* in the semantic representations) in addition to the other commonly assumed semantic types of individuals and truth-values (Heim and Kratzer, 1998).[1] A discussion of whether this semantic type is a universal primitive type in all languages, or whether languages vary in the presence of degrees and the extent to which they are exploited in the language's semantics (Beck et al., 2004, 2009; Bochnak, 2011) is delayed until Chapter 6.

1.1.2.1 The 'standard' approach

One standard analysis of comparatives (von Stechow, 1984, reviewed in detail in Beck, 2011) holds that adjectives denote functions from degrees to individuals, or in other words have semantic type $< d < et >>$. The meaning for an adjective like *tall* is shown in (4). The comparative morpheme has a meaning of type $< dt < dt < t >>>$, as shown in (5). I assume that the comparative morpheme compares the maximal degree of one degree property to the maximal degree of another degree property (see Rullmann, 1995), asserting that the first is greater than the second.

(4) $[[tall]] = \lambda d_d.\lambda x_e.x$ is d-tall.

(5) $[[er]] = \lambda P_{dt}\lambda Q_{dt}[MAX(Q) > MAX(P)]$

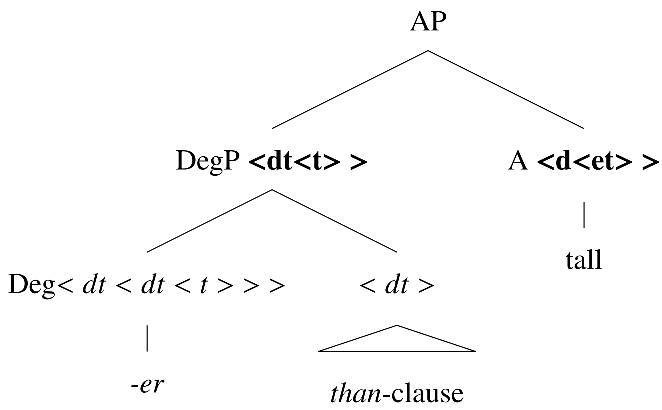
Under this view of the semantics, the syntax of comparatives requires the adjective and the comparative morpheme to form a constituent - a degree quantifier (DegP) - as shown in (11). However, this degree quantifier cannot compose with the adjective directly due to a clash in semantic type. The adjective must compose with an argument of type d, but the type of the DegP is $< dt < t >>$. The degree quantifier must move to its scope position to be interpreted (Heim, 2000), and leaves a trace of type d.[2] This trace is of the correct semantic type to compose with the meaning of the adjective.

---

[1]In this dissertation, events and possible worlds will not be relevant to the discussion, and so I leave these out.

[2]See Heim (2000) for an in-depth investigation into the scope of degree quantifiers in comparative clauses.

(6) Type mismatch prior to movement of DegP:



The standard analysis of comparatives captures intuitions about the compositional semantics of comparatives. Another advantage of this approach is that it captures the selectional restrictions in comparatives (*more*, *fewer* and *less* select for *than*, while the equative *as many* selects for a comparative clause headed by *as*). However, there are several facts about comparatives that do not follow straightforwardly from this account.

First, while the standard analysis produces an appropriate semantics for comparatives, it has the limitation that further operations must be done to obtain the observed surface word order. Normally the comparative morpheme *-er* is pronounced as a part of the gradable adjective (e.g, *taller*) or can combine with elements like *many* (creating *more*) or *few* (creating *fewer*) (Bresnan, 1973). However, as Bhatt and Pancheva (2004) observe, in general the *than*-expression must be dislocated from the comparative morpheme, as shown for the comparative ellipsis examples in (7).

(7) Bhatt and Pancheva (2004):11

a. * Ralph is [more than Flora is] tall.

cf. Ralph is taller than Flora is.

b. * Ralph is [more than her] tall.

cf. Ralph is taller than her.

In the standard approach, the comparative morpheme does not form a constituent with the adjective, which fails to predict the surface morphology. A solution to this problem is to adopt an analysis in which the comparative morpheme does form a constituent with the adjective. However, for such an architecture to compose semantically, the meanings of gradable adjectives would have to be different from those posited by the standard account. In the next section, I will discuss an account by Kennedy (1997, 1999) that gives a different semantics to adjectives and uses an architecture that straightforwardly captures the morphological realization of comparatives.

1.1.2.2 The measure phrase analysis of gradable adjectives

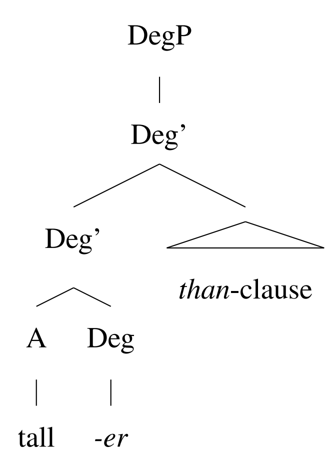
Kennedy (1997, 1999), following Cresswell (1976)), argues for an analysis of the syntax and semantics of comparatives that better captures the morphological facts regarding comparative adjectives. In this account, the comparative morpheme first forms a constituent with the adjective, and later these compose with the *than*-clause. This analysis requires a different semantics for adjectives from the standard view. Kennedy (1997, 1999) proposes that adjectives are *measure functions*, which are functions from objects to degrees. Example (8) shows that under this account, *tall* would have a meaning that related objects to degrees through δ, a measure function for height.

(8) $[[tall]] = \lambda d_d \lambda x_e [\delta_{tall}\ (x) \geq\ d]$

The comparative morpheme, defined in (9), takes as arguments a measure function G (from the gradable adjective) and a degree (from the standard of comparison) to form a complete semantics for the comparative. The architecture that Kennedy (1997, 1999) uses would give a structure as in (10).

(9) $[[more/-er]] = \lambda\ G\ \lambda d\ \lambda x\ [MORE(G(x))(d)]$

(10)



While this structure can straightforwardly predict the synthetic forms of comparative adjectives in the surface form, it loses some insights captured by the standard approach. While I do not believe that the differences between these two accounts would be critical in the investigations pursued in this dissertation, in the next section I will present an account by Bhatt and Pancheva (2004) that brings together aspects of both accounts.

1.1.2.3 Late merger of Degree Clauses

Bhatt and Pancheva (2004) modify the standard analysis of comparatives in order to better account for the surface form of English comparatives, The account introduces two main claims. The first claim is that there is covert, LF-movement of the comparative morpheme to its scope position in the structure. Subsequent to this movement, *than*-clauses are late-merged adjoining to the comparative morpheme. With this modification, Bhatt and Pancheva (2004) claim that the standard approach can avoid some of the problems from which it previously suffered.

As a starting point, under Bhatt and Pancheva (2004)'s account, the initial structure for a comparative would be as in (11), before the *than*-clause is merged.

(11) Bhatt and Pancheva (2004): 17

AP

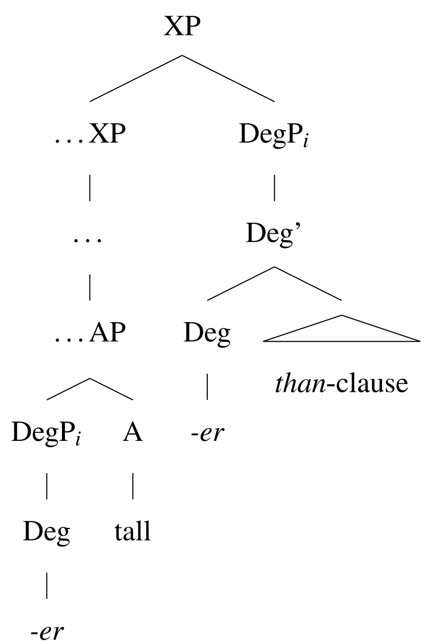
DegP A

Deg tall

-er

The comparative morpheme has a meaning is type $< dt < dt < t >>>$, as shown in (5).Under the standard account, the constituent (DegP) formed by the comparative morpheme *-er* and the than-clause then undergoes QR to its scope position (see Heim, 2000), leaving behind a trace (or copy) interpreted as type *d*. In this modified account, the comparative morpheme undergoes movement before the comparative clause is merged. This movement is covert, which allows the comparative morpheme to be adjacent to the adjective at the stage in the derivation wherein it is spoken. Then, the comparative clause is adjoined to *-er* at its scope position, capturing the semantic facts regarding the scope of the degree quantifier. This adjunction is achieved through a process of *late merge*, originally argued for relative clauses by Lebeaux (1988) (see also Fox and Nissenbaum, 1999; Fox, 2002 for arguments for late merger of relative clauses). The representation obtained by Bhatt and Pancheva (2004)'s account is shown in (12).

(12) Modified from Bhatt and Pancheva (2004): 19



Proposing the late merger of comparative clauses avoids the conflict between the phono-morphological and semantic needs of comparatives. Under this account, the surface facts regarding the pronunciation of the comparative morpheme together with an adjective is captured by the lower, spoken copy of *-er*. However, as in the standard account, the higher, interpreted copy of *-er* forms a constituent with the comparative clause and this constituent sits in its scope position.

1.1.2.4 *Than*-phrases and clauses

One important debate in the syntactic literature on comparatives is the nature of the complement to *than*. Hankamer (1973) argued for two *than*s in English; one that is a complementizer and one that is a preposition. This difference has been characterized as *phrasal* vs. *clausal* comparatives. As an example, one of the arguments that Hankamer presents for this ambiguity is the fact that while *comparative clauses* (the clauses that are complements to *than*) are islands for extraction (e.g., 14), examples like (15), in which the extracted component would have been the only spoken content in the complement to *than*, are not ungrammatical (although they may be degraded depending on a speaker's intuitions about preposition stranding).

(13) John is taller than Bill (is).

(14) *Who is John taller than __ is?

(15) Who is John taller than __?

Another common argument for the phrasal/clausal distinction is that complements to *than* may appear in accusative case (e.g., 16), which is not predicted if they are understood as the subject of an underlying clause (17).

(16) John is taller than her.

(17) John is taller than she/*her is.

Accounts that posit an underlying difference between phrasal and clausal comparatives are referred to as *direct* analyses (Hankamer, 1973; Pinkham, 1985; Osborne, 2009, inter alia). Other accounts (e.g., Lechner, 2001, 2004) propose a *reduction* analysis of comparatives, wherein all complements to *than* are underlyingly clausal, and undergo reduction operations that render some of the underlying material silent. Other accounts propose that languages vary with respect to whether they have a phrasal/clausal distinction (Bhatt and Takahashi, 2011a). Under a reduction analysis, the accusative case of the remnant in (16) must somehow be explained, for example by a mechanism that allows for Exceptional Case Marking (Pancheva, 2006, although this account does posit some underlying differences between phrasal and clausal comparatives). The phrasal/clausal distinction will be discussed further in Chapter 2, where I argue that there is a limited use of phrasal comparatives in English and that this difference has an influence on the processing (and pattern of acceptability) of comparatives.

1.1.2.5 Comparative Deletion and Subdeletion

In comparative clauses, there is always some linguistic material that is understood despite not being spoken. Many of the reduction operations that apply in comparative clauses are merely the same ones that happen in more general circumstances. For example, comparative clauses can undergo operations like Verb-Phrase ellipsis, pseudogapping and gapping. Compare the comparative examples in (18a), (19a) and (98) to their VP ellipsis, pseudogapping and gapping counterparts in the (b) examples.

(18) a. Bob bought a more expensive car than Ron did Δ.

Δ = buy a *d*-expensive car

b. Bob bought an expensive car, and then Ron did Δ.

Δ = buy an expensive car

(19) a. Bob wrote more letters to Mary than Ron did Δ to Sarah.

Δ = write *d*-many letters

b. Bob wrote letters to Mary, and Ron did Δ to Sarah.

Δ = write letters

(20) a. Bob wrote more letters to Mary than Ron Δ to Sarah.

Δ = (did) write *d*-many letters

b. Bob wrote letters to Mary, and Ron Δ to Sarah.

Δ = (did) write letters

The only difference between the deleted material in the (a) and (b) examples above is that the comparative (a) versions involve the deletion of a degree variable. This degree variable cannot be spoken in any comparative clauses. When the degree variable as well as an adjective (21a) or a quantity (21b) is deleted, this operation is called *Comparative Deletion*. When the degree variable alone is deleted, the resulting construction is called *Comparative Subdeletion* (Bresnan, 1975). Constructions involving comparative deletion necessarily involve comparing two degrees on the same scale., e.g., width or number of apples. Examples involving comparative subdeletion involve a comparison of two degrees on different scales (e.g., width and length or number of apples vs. number of pears). I will refer to examples of comparative subdeletion as *subcomparatives*.

(21) a. The truck is wider than the compact car is ~~*d-wide*~~

b. Paige picked more apples than Colin picked ~~*d-many apples*~~

(22) a. The truck is wider than the compact car is ~~*d-*~~ long

b. Paige picked more apples than Colin picked ~~*d-many*~~ pears.

The degree variable cannot be spoken in (sub-)comparatives, as is shown in example (23).

(23) The truck is wider than the compact car is *10ft/*that/*very long

Comparative Deletion (CD) and Comparative Subdeletion (CSD) will be discussed througout the dissertation, and particularly in Chapters 2-4. The analysis of CD and CSD is inextricably linked to the theory of the internal structure of *than*-clauses (for example, whether and what movement operations *than*-clauses include). While Chapter 4 will discuss analyses of *than*-clauses in depth, here I will present some of the main observations and arguments Bresnan (1975) gives for a unified analysis of comparative deletion and subdeletion.

Ross (1967) observes that Comparative Deletion obeys island constraints. Three examples of CD in which island constraints are violated are shown in (24). The adherence of CD to island constraints is an indication that movement is involved in these structures. Comparative Subdeletion, as shown in (25), adheres to these constraints as well.

(24) Bresnan (1975), from Ross (1967):

a. *Complex NP Island:*

* Wilt is taller than he knows a boy who is __.

b. *Coordinate Structure Island*:

* Wilt is taller than Bill is strong and __.

c. *Sentential Subject Island*:

* Wilt is taller than that he is __ is generally believed.

(25) Bresnan (1975):

a. *Complex NP Island*:

*We ended up buying as many oranges as we had discussed a plan to buy __ apples.

b. *Coordinate Structure Island*:

*Dean drank more booze than Frank ate a lot of Wheaties and Sammy drank __ milk.

c. *Sentential Subject Island*:

* You have as many reasons for leaving him as that he has __ for leaving you is likely.

While CD and CSD behave alike with respect to island constraints, the constituents they target behave differently with respect to question formation. While elements like those deleted by CD can be moved in questions (e.g., 26a), elements like those deleted in CSD cannot (26b).

(26) Bresnan (1975):132

a. How many books did she send __ to you?

b. *How many did she send __ books to you?

Bresnan (1975)'s analysis of CD and CSD involves deletion of a variable corresponding to a degree. In the framework Bresnan is working in, grammatical transformations (including deletion) are subject to a relativized 'A-over-A' principle. This principle "has the effect that if a transformation applies to two constituents of the same type and gives no information about which is to be chosen, the maximal, or dominating, one is chosen." (Bresnan, 1975: p. 64). In the case of comparatives, maximality is determined by recoverability. In the case of CD, the entire AP or NP is recoverable with respect to the associate of comparison, while with CSD only a smaller deletion is possible. The A-over-A principle is responsible for the pattern in (27-28). While example (27) is a grammatical example of CSD, example (28) has deletion of a constituent smaller than what would be recoverable, and is therefore ungrammatical.

(27) John built taller shelves than Bill built ~~*d-tall*~~ cabinets.

(28) * John built taller shelves than Bill built ~~*d-tall*~~ shelves.

Given that the degree variable must be unspoken in both CD and CSD, CSD has often been taken to be the basic case for comparatives (see e.g., Lees, 1961). Kennedy (2002) reviews the evidence for both uniform and distinct accounts of comparative deletion and subdeletion before finally supporting a modified uniform analysis of the two types of deletion. Kennedy's account will be discussed in detail in Chapter 4.

1.1.3 Cross-linguistic variation in comparatives

The typology of comparatives across the world's languages shows a large variety in the way comparison is encoded morphologically and syntactically (see Stassen, 1985). Some of the questions addressed in this dissertation are focused on the processing of English (or English-type) comparatives (e.g., Chapter 2). Preliminary evidence from a study performed in Japanese is presented in Chapter 4 to help to decide between an English-specific and a language-general hypothesis. Other lines of inquiry in this dissertation seek to uncover what could be facts about the processing of comparatives regardless of their particular syntactic form (e.g., Chapter 6). In Chapter 6, I will summarize the literature on the underlying semantic differences that have been proposed to exist between comparatives across languages. Going forward, I believe that the cross-linguistic experimental study of comparatives will be an important domain for research into the level of representation at which cross-linguistic differences in comparatives should be modeled, and will also help to determine the level at which effects in the processing of comparatives should be modeled.

1.2 Psycholinguistic background

Because issues of both representation and processing of comparatives are at issue in this dissertation, the psycholinguistic investigation of comparatives presented here is performed with a close eye on theories of the underlying structure and semantics of these constructions. Implicit in this sort of investigation is the assumption that the linguistic representations formed during sentence processing are constrained and defined by a grammar. I further make the assumption that there is a close connection between the structures built by the parser and their semantic interpretation.

I will assume that the parser behaves economically, namely that a principle of Minimal Attachment (Frazier, 1978, 1987a) is at play in sentence processing, favouring simpler structures (with fewer nodes) over more complex ones. This principle will be important especially in Chapter 2, where a simpler comparative structure is shown to be readers' initial preference, causing a garden path effect when this analysis turns out to be erroneous. An economy principle like Minimal Attachment also requires the assumption that the parser gives priority to one analysis (the more minimal one) in cases of temporary ambiguity.[3] I'll assume that disconfirmation of the simplest analysis requires revision of the linguistic representation, which, depending on the circumstances may be easy and successful or may cause extreme processing difficulty or failure of reanalysis.

In addition to building the syntactic structure required, comparatives often involve the 'filling in' of a gap site left by comparative deletion, or in the case of subcomparatives, deciding where to attach a degree argument in the absence of an obvious gap. In comparative clauses that have undergone comparative deletion (e.g., 29), the gap site (marked by Δ) corresponds to a degree variable an adjective or quantity and the associated noun in this case *d-many people*. In cases of comparative subdeletion (e.g., 30), the unspoken material is only the degree argument.

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[3]Although, I will discuss parallel accounts of sentence processing where these might make relevant predictions (e.g., Levy, 2008).

(29) More people came the the party than I had invited Δ.

$\Delta = d$-many people

(30) More men came to the party than I had invited Δ women.

$\Delta = d$-many

Whether gaps in comparative clauses behave like other filler-gap constructions is an empirical question. This question will be discussed further in Chapters 2-4. For more well studied types of filler-gap relationships, such as wh-movement, I assume an Active Filler strategy (Crain and Fodor, 1985; Stowe, 1986; Clifton and Frazier, 1989; Frazier and Flores D'Arcais, 1989; Omaki et al., 2012; Wagers and Phillips, 2012) in which the presence of a filler commences an active search for possible gap sites during on-line processing. The evidence motivating this assumption comes from the existence of so-called of filled-gap effects. For example, (Frazier and Clifton Jr., 1989; Stowe, 1986, among others) have shown that NPs have longer reading times when they are in a position that could have served as a gap corresponding to a moved *wh*-item. For example, because the direct object of *urge* is a potential gap site for the filler *who* in the example (113a) from Frazier and Clifton Jr. (1989), the language processing mechanism will attempt to complete the dependency. When this potential gap site turns out to be filled by an overt NP (*the guests*), processing difficulty ensues. This effect cannot be attributed to the mere presence of a question rather than a declarative sentence; Stowe (1986) found a similar delay on *us* in (32b) as compared to (32a), because of the opportunity for a gap following the verb *bring* as shown in (32c) despite both being declarative sentences with embedded questions.

(31) Frazier and Clifton Jr. (1989)

a. Who did the housekeeper from Germany urge the guests to consider?

b. The housekeeper from Germany urged the guests to consider the new chef.

(32) Stowe (1986)

a. My brother wanted to know who __ will bring us home to Mom at Christmas.

b. My brother wanted to know who Ruth would bring us home to __ at Christmas.

c. My brother wanted to know who Ruth would bring __ home to Mom at Christmas.

In addition to grammatical knowledge, pragmatics and conceptual/world knowledge are also important sources of information used by the parser to construct a linguistic representation from an incoming stream of speech or written words. In Chapter 5, I address the priority given to world knowledge (of the lexical/conceptual sort) and the timecourse of its integration during on-line processing of comparatives.

As mentioned above, comparatives have the property of containing material that semantically interpreted despite being silent. In addition to the material deleted by operations such as comparative deletion, VP ellipsis and gapping, constituents headed by *than* always have an unspoken degree. The degree argument in (33), for example, cannot be filled in overtly by a degree of height like *7ft*. Some studies, for example those studying semantic coercion, have found processing costs associated with unspoken semantic material (Piñango et al., 1999, 2006; Brennan and Pylkkänen, 2008).

(33) The table is wider than the door is (*7ft) tall.

In Section 1.3, I will summarize some of the cognitive-psychological literature on how mental comparisons are made. The results discussed there are meant to speak to how humans make comparisons (mainly of objects in the visual world or in our conceptual knowledge). Knowing what makes comparisons cognitively easier or more difficult (for example the effect of the relative or absolute location of two points on the relevant scale) is interesting and important, and will be especially relevant to the work presented in Chapter 6, where I discuss the complexity of comprehending comparatives in a reading task. However, what I am primarily concerned with is how humans build and interpret comparison *in language*. Separating comparison as encoded in language from comparison per se is not easy, and there are lines of investigation that link the two together, for example by proposing a relationship between the meaning of a comparative quantifier and the process of making a comparison (see Pietroski et al., 2009; Hackl, 2009a; Lidz et al., 2011; Tomaszewicz, 2011; Scontras et al., 2012, discussed in Chapter 6).

1.2.1 Previous relevant psycholinguistic work

While the literature on processing comparatives is relatively small, there are some related areas that have benefited from psycholinguistic inquiry. Some of these lines of inquiry will be discussed in detail in upcoming chapters, but others have a less direct, though still important, relationship to the new work presented in this dissertation. These include the processing of so-called *comparative illusions*, the role of parallelism in processing comparatives, and the processing of scalar adjectives. I will summarize the literature in each of these areas below.

1.2.1.1 Processing comparative illusions

One recent line of research on comparatives focuses on so-called *comparative illusions* (Fults and Phillips, 2004; Phillips et al., 2009; Wellwood et al., 2009), as in (34). These examples have been known to give the hearer or reader the initial impression of grammaticality, despite being semantically uninterpretable. Previously, they had been analyzed as a syntactic blend between (35a) and (35b) (Townsend and Bever, 2001).

(34) Phillips et al. (2009): 29, originally due to Montalbetti (1984)
More people have been to Russia [than I have].

(35) Townsend and Bever (2001)

a. More people have been to Russia than I.

b. People have been to Russia more than I have.

Fults and Phillips (2004) conducted experiments to determine whether naive English native speakers rate comparative illusion sentences as being more acceptable than patently ungrammatical comparatives. They found that comparative illusions had ratings as high as grammatical phrasal comparatives such as (36b) and significantly higher than the ungrammatical no-ellipsis and no-extraposition conditions (36c-36d).

(36) Non-illusion Conditions, Fults and Phillips (2004)

a. More people have been to Russia than elephants have.

b. More people have been to Russia than just me.

c. *More people have been to Russia than I have been to Russia.

d. * More people than I have have been to Russia.

Fults and Phillips note the puzzling lack of illusion when the *than*-phrase is not extraposed, as in (36d). They present preliminary questionnaire results suggesting, however, that extraposition is not enough to generate the grammatical illusion. In their third experiment, Fults and Phillips compare *base* and *extraposed* positions of *than*-phrase s in *comparative deletion* contexts, such as (37). They claim that the extraposed version (37a) is merely unacceptable rather than ungrammatical.

(37) Fults and Phillips (2004) (judgments theirs):

a. *Taller people have been to Russia than I am.

b. Taller people than I am have been to Russia.

In contrast to the results from the original illusion study, extraposition led to a reduction in acceptability with the comparative deletion materials. Fults and Phillips conclude that the comparative illusion is present with comparative ellipsis and not comparative deletion because comparative gaps are preferentially filled with the closest possible antecedent. If the closest possible antecedent (*been to Russia* in 34 and 37a) fits syntactically with the sentence, then an illusion is generated. This occurs in (34), where the filled gap creates *than I have been to Russia*, but not in (37a), where the filled gap creates **than I am been to Russia*.

Wellwood et al. (2009) suggest that the essential component to the comparative illusion is a predicate that is plausibly repeatable, allowing reader/hearers to coerce an event comparison interpretation like (38b) for (38a). They attribute comparative illusions to semantic factors rather than syntactic ones as proposed by Fults and Phillips (2004).

(38) Wellwood et al. (2009)

a. More Americans have been to Russia than I have.

b. Americans have been to Russia *more* than I have.

Wellwood et al. (2009) also provides an indirect experimental test of whether a so-called 'just me' interpretation plays a role in generating comparative illusions. Wellwood et al. varied whether coercion of comparative illusions into a such a reading was possible or impossible.

(39) a. More girls drive to school than **she** does.

b. *Possible coercion*: More girls drive to school than just her.

a. More girls drive to school than **he** does.

b. *Impossible coercion*: *More girls drive to school than just him.

Although not all of the details of this manipulation are presented, the authors report that there was no effect of the possibility of a 'just me' reading in the acceptability rating data. A final difference between the two investigations into comparative illusions discussed here is that contrary to Fults and Phillips (2004), Wellwood et al. do not find significant differences in acceptability between ellipsis examples and those without ellipsis.

While I will not provide an account of comparative illusions in this dissertation, comparatives with 'just me' interpretations fit into a larger set of comparatives that I call subset comparatives, which will be the focus of Chapter 5. In a subset comparative, the complement to *than* defines a set that is a subset of the associate of comparison. Such a reading may have been possible in the non-pronoun conditions of Wellwood et al. (2009)'s study. For example, in *More workers were laid off from the plant than managers were*, it is not fully explicit that managers are not part of the set of workers. Chapter 5 will also show that certain types of coercion are possible when it comes to comparative clauses, and in particular one of the results of a pilot experiment will show an unexpected mapping between a syntactic form and a particular interpretation when favoured by discourse factors.

1.2.1.2 Parallelism in processing comparatives

Another line of research on processing comparatives comes from an investigation into the processing of ellipsis. As mentioned above, comparatives often undergo Comparative Deletion, which deletes a Degree Phrase composed of a degree variable plus an adjective (e.g., *d-old* in 40a) or quantity (e.g., *d-many books* in 40b).

(40) Lechner (2001): 1

a. John is older than Mary is Δ. (Δ = *d*-old)

b. John read more books than Mary read Δ. (Δ = *d*-many books)

Comparative *ellipsis*, however, involves deletion of more than just a Degree Phrase. In (41) the entire VP *read d-many books* has been elided. For those who maintain a reduction analysis of comparative clauses, reduction operations can eliminate all spoken material in the comparative clause except for one remaining DP (42).

(41) John read more books than Mary did Δ. (Δ = read *d*-many books)

(42) John read more books than Mary Δ. (Δ = read *d*-many books)

Deletion of enough material from the comparative clause can cause ambiguities to arise. For example, Carlson (2002) studied sentences such as (43), which are ambiguous between two readings. In each case, what is being compared is a degree of frequency (or *often*-ness). However, the remnant in the *than*-constituent *Sonya* can be understood either as a subject, as shown in (43a), or as an object (43b).

(43) Tasha called Bella more often than Sonya.

a. *than*-phrase interpretation: than **Sonya** ~~called Bella *d*-often~~. (subject analysis)

b. *than*-phrase interpretation: than ~~Tasha called~~ **Sonya** ~~*d*-often~~. (object analysis)

Carlson found that readers are sensitive to lexical parallelism in choosing an interpretation of sentences like (43a). In a questionnaire study, parallelism (proper names with the same gender) between main clause subject and comparative clause remnant resulted in 68% subject analyses, while neutral parallelism elicited only 35% subject analyses. While not directly related to the studies presented here in the dissertation, the results found by Carlson (2002) speak to the expectations that readers have for the material in the comparative clause. These expectations will be at issue in Chapters 2-4.

1.2.1.3 Processing adjectives

While most of this dissertation will deal with comparisons of cardinality (using *more* or *fewer*), Chapter 6 will look explicitly at the differences between processing sentences with cardinality comparisons and those with comparisons along scales of gradable adjectives. This section will summarize some of the experimental research that has examined how gradable adjectives and the scales they imply affect language processing, and how adjectives influence sentence processing in a visual context.

One line of inquiry into the processing of gradable adjectives are studies of so-called minimum standard and maximum standard adjectives. Adjectives like *clean* point to the highest degree on the scale from *dirty* to *clean*, while *dirty* may describe anything beneath this maximum standard (Rotstein and Winter, 2004; Kennedy, 2007b). Frazier et al. (2008) confirmed expectations based on this analysis. They found a reduced proportion of “acceptable" responses in a speeded acceptability judgment for (44b). which has a conflict between the modifier *slightly* and the maximum-standard quality of the adjective *clean*, as compared to the other conditions in (44).

(44) Frazier et al. (2008), Experiment 1

a. I would say that this table is clean.

b. I would say that this table is slightly clean.

c. I would say that this table is dirty.

d. I would say that this table is slightly dirty.

Frazier et al.'s second experiment did involve comparatives in the target (second) clause of their materials. The results of the experiment showed reduced acceptability (again in a speeded acceptability judgment task) for sentences like (45a) as compared to (45b). Frazier et al. (2008) interpret this result as evidence for the special maximum standard quality of adjectives like *pure*. Once something has been deemed pure, it is odd to say that it is less pure than something else.

(45) Frazier et al. (2008), Experiment 2

a. These juices are absolutely pure, but the mango juice is more impure than the papaya.

b. These juices are absolutely impure, but the mango juice is purer than the papaya.

One very interesting point that is noted in the literature on minimum and maximum standards is that the minimum or maximum standard interpretation disappears when the adjective appears in its comparative form. For example, while Frazier et al. confirmed the intuition that modifying maximum standard adjectives like *clean* with modifiers like *slightly* gives rise to a conflict in interpretation (e.g., 46), the same modifier with the comparative form of the adjective is felicitous. Whether there are any lingering effects of maximum or minimum standards in processing time with comparative adjectives is an open question.

(46) # The table was slightly clean.

(47) This table is slightly cleaner.

Bogal-Allbritten (2011) also deals with the processing of adjectives with different scale structures, in particular *negative evaluative* adjectives. Negative evaluative adjectives are ones like *rude* or *ugly*, which encode a negative judgment about the NP they modify. Bogal-Allbritten tested whether negative evaluative adjectives show the same conflict between modifiers like *slightly* as the maximum standard adjectives in Frazier et al. (2008). In a rating study, sentences with positive and negative evaluative adjectives were shown to have a similar pattern of acceptability with respect to modification by diminishers like *slightly* or *a little* as maximum and minimum standard adjectives. Namely, diminishing the positive evaluative or maximum standard adjective caused a greater decrease in acceptability than diminishing the negative evaluative or minimum standard adjective. A second study compared evaluative adjectives to dimensional adjectives like *narrow*, and found that diminishing modifiers did not have the same effect on these as they did on maximum standard or positive evaluative adjectives. These findings allow Bogal-Allbritten to ask the question of whether aspects of adjectival meaning like evaluativity or minimal/maximal standards are a part of the core meaning of the adjective, or whether these parts of the meaning are coerced in sentential contexts. Bogal-Allbritten conducted a self-paced reading experiment using dimension and negative evaluative adjectives modified either by a diminisher or *too*. For the dimensional adjectives, a pretest showed that adding a diminisher like *slightly* often (on 39% of trials) receive a 'too-much'-type reading so that the preferred interpretation of (48b) and (d) are likely to have a similar meaning. The hypothesis regarding coercion was that given the lack of evaluative or maximum standard meaning for dimensional adjectives, coercion must be involved in order to compose the diminisher and adjective. If negative evaluative adjectives undergo a similar process of coercion, then the two adjective types should pattern alike. However if the negative evaluative aspect of the meaning of adjectives like *boring* is a part of the adjective's core meaning, then one might expect a smaller difference between bare diminishers and diminishers with *too* for negative evaluative adjectives.

(48) Sample item, Bogal-Allbritten (2011):

Context: Mr. Richards suggested that Ms. Smith show a film on the Massachusetts railway system to students during civics studies class.

a. Ms. Smith thought that the film was slightly boring *to interest* her students, so she showed another film.

b. Ms. Smith thought that the film was slightly long *to interest* her students, so she showed another film.

c. Ms. Smith thought that the film was slightly too boring *to interest* her students, so she showed another film.

d. Ms. Smith thought that the film was slightly too long *to interest* her students, so she showed another film.

The results of the experiment showed that the difference between critical control conditions on the spillover region was greater for dimensional adjectives than for negative evaluative adjectives, suggesting that evaluativity is part of the adjective's meaning.

Syrett et al. (2010) showed that children are sensitive to properties of gradable adjective meaning in almost the same way adults are. In a task where children were asked to 'help a puppet learn how to ask for things' by giving the puppet the object that it asked for. While children gave the longer of two items when they were asked for 'the long one,' they did not give the more spotted of two items in the majority of cases when asked for 'the spotted one,' indicating that the children had encoded the minimum standard meaning of adjectives like *spotted*. The children performed the same as adults except for in the condition using the maximum standard adjective *full*, where they treated *full* as though it were a relative-gradable adjective without a maximum standard (e.g., *long*) and gave the more full between two non-full glasses. A subsequent experiment showed that the children give a gradable interpretation to *full* less often when they had seen the glass that met the maximum standard of *fullness*, and that response times were longer in the infelicitous-full conditions than the other conditions. Syrett et al. take this as an indication that the children knew that neither of the objects was, strictly speaking, *full*, but nonetheless allowed a relative use of the adjective.

1.2.1.4 The use of adjectival meaning with respect to a 'visual world'

Sedivy et al. (1997) provides another study of the use of an overarching contextual standard and the use of a relative standard in processing scalar adjectives, this time in an adult population during on-line sentence processing. The authors present two visual-world eyetracking studies that differed in the experimental task that subjects were asked to perform. In their first experiment, subjects were asked to answer a yes-no question containing the scalar adjective-modified noun (e.g., "Is there a tall glass?") while their eye movements around a visual array were recorded. In their Experiment 2, subjects were asked to perform an action involving the modified noun (e.g., "Pick up the tall glass and put it below the pitcher."). The instruction was the same for all conditions of an item.

The experimental manipulation was in the objects depicted in the visual array. The *target* object (e.g., the tall glass) was a typical exemplar of the modified noun in half of the trials, and in half of the trials the target was atypical for the modified noun phrase, and rather best described using an unmodified noun. The typicality of the exemplars was determined in a separate study. All of the displays contained a *competitor* object, which was an object that had a higher degree than the target on the scalar adjective scale (e.g., tallness). The competitors were different types of objects from the targets (e.g., a pitcher as opposed to a glass). Finally on half of the trials the display included an overt *contrast* object, which was the same type of object as the target but at the other end of the adjective scale (e.g., a short glass).

In their first experiment, Sedivy et al. found that subjects made an eye movement to the contrasting object more often (47% of trials) than to an unrelated object in the same physical location on no-contrast trials (7% of trials). In addition, Sedivy et al. found an increase in looks to the competitor object when no contrasting object was present. Eye movements to the competitor object were on average earlier than eye movements to the contrast object (198ms vs. 472ms after the onset of the head noun), which the authors interpret as a difference in the linguistic trigger for the saccade: eye movements to the competitor were due to information from the scalar adjective, while looks to the contrast object took place in response to information about the head noun. The authors found that subjects responded “yes" to the questions a very high proportion of the time for both typical and atypical exemplars of the modified noun when an overt contrast was present (95-93%). However, the proportion of “yes" responses in the atypical exemplar condition diminished to 58% when no contrasting object was present. However, the latencies of making a “yes" response were slower for atypical objects in both the no-contrast and contrast conditions. Sedivy et al.'s Experiment 2, which had a task requiring the subject to perform an action, showed different effects. In the contrast condition, eye movements to the target had shorter latencies than in the non-contrast condition. Without the yes-no question task, typicality of the target did not have a reliable influence on eye movements, although there was a numerical trend toward faster movements to typical targets in the no-contrast condition. As in Experiment 1, there were more eye movements to the competitor in the no-contrast condition, and more eye movements to the contrasting object than to a similarly-placed distractor object in the non contrasting conditions.

The studies by Sedivy et al. provide evidence that subjects make use of both contextually determined standards of comparison and (in this case, visually) supplied standards in the processing of scalar adjectives. However, these two methods of processing scalar adjectives may not be employed in the same circumstances. The overall typicality of a target had an effect on the proportion and latency of *yes* responses in Experiment 1, but did not have a reliable effect on eye movement latencies to the target in either experiment. What seems to matter most in determining eye movement latencies to the target is the overt contrasting object in the visual display. The proportion of looks to the contrast and competitor objects in across their experiments reveals an interesting trade-off. When no overt contrasting object was present, subjects made many eye movements to the competitor on between 30 and 40% of trials. In the contrast conditions, however, there were many fewer eye movements to the competitor object and more to the contrasting object. As Sedivy et al. note in their discussion, these results seem to indicate that a visually supplied standard of comparison is preferred over a standard that makes use of overall contextual knowledge or general world knowledge. However, Sedivy et al., stress that the semantics of adjectives must include a possibility for both implicit and explicit standards of comparison.

The studies presented in this dissertation all involve reading target sentences, rather than listening to sentences and interpreting them with respect to a visual array. However, the principles that guide the use of adjectival information as relative or absolute are likely to carry over to written sentence comprehension and in particular the mental *instantiation* of linguistic input (Garnham, 1987). Instantiation will be discussed further in Chapter 6.

1.3 Comparison studies in cognitive psychology

This chapter focused on the processes involved in comprehending comparison encoded in language, rather than the mechanisms used by humans in general to make comparisons. However, the question of how humans make comparisons has long been studied in the cognitive psychological literature outside of psycholinguistics. Researchers have studied reaction times and the brain regions involved in making comparisons of digits (e.g. Moyer and Landauer, 1967; Banks et al., 1976; Dehaene, 1989; Foltz et al., 1984; Pinel et al., 2001), arrays of dots (e.g. Buckley and Gillman, 1974), objects denoted by words (e.g. Banks and Flora, 1977; Foltz et al., 1984; Moyer, 1973), pictures (Banks and Flora, 1977, e.g.) among other visual displays, with the goal of discovering the existence and nature of human ‘internal psychophysics’ (Moyer, 1973). This literature does not generally include comparisons of pluralities, and therefore may not be directly related to the results discussed in Chapter 6 and the study by Scontras et al. that is cited there, it is worth going over some of the main results in order to inform predictions for future research.

While many early studies involved comparisons of single digits, objects, etc., Just and Carpenter (1976) performed a study investigating comparisons of cardinality by tracking subjects’ eye movements while comparing groups of dots. Subjects were presented with two groups of dots and were asked to judge which was greater or smaller in cardinality, as indicated by an instruction word on the same screen (*MORE* or *LESS*). Just and Carpenter found that while gaze duration on the smaller of the two groups was linearly related to the number of dots in that group (with a 26ms increase for each additional dot), gaze duration on the larger group did not similarly vary with the group’s cardinality. Based on their data and previous studies in the literature, Just and Carpenter support a two-process model for comparison. They propose that the reason for the gaze duration results they found is that subjects were counting dots in each group until they exhausted the dots for one group, which was then known to be the smaller group. However, they also found effects similar to those found in single object comparisons. For example, they found a so-called *split* effect in response latency, wherein subjects were faster to respond as the difference in cardinality between the two groups increased. This is similar to effects that had been found by other researchers in numerical comparison of digits (e.g. Banks et al., 1976; Buckley and Gillman, 1974; Moyer and Landauer, 1967). Just and Carpenter attribute split effects to a quick judgment of category membership between the groups. For example, if one group is judged to belong to the category *large* and the other is judged to belong to the category *small*, then it is easy to judge which group is larger. Other studies have found similar effects of category or *congruity* of compared objects to the adjective given as an instruction (Banks et al., 1976). Banks et al. found a penalty for reaction times in number comparison when two digits classified as large were asked to be compared using the instruction “choose smaller." Kosslyn et al. (1977) found that category membership played a role in comparison even for novel stimuli, which were associated with a category (*large* or *small*) in a pre-test. However, Kosslyn et al. found that subjects were generally faster when asked to choose the larger of two figures than they were in choosing smaller of two figures.

Several investigations have sought to determine whether numerical comparison is different from other types of psychophysical comparisons in terms of the cortical areas involved. Cohen Kadosh et al. (2005) tested three types of comparison using fMRI: number, luminance and physical size. In their behavioural data, Cohen Kadosh et al. showed that the *split* effect was smaller for numerical comparison than for the other judgments. With respect to cortical involvement, the authors found that there was a large pattern areas that were activated for all types of comparison. However, they also found activation in the left Intra Parietal Sulcus (as well as an area in the right Middle Temporal Gyrus) that was specific to numerical comparison, contrary to other reports that the networks for the three types of comparison are the same (Pinel et al., 2004).

The studies cited here form only a portion of the literature on mental comparison. However, the literature mainly deals with either direct psychophysical judgments (e.g., luminance or physical size), or slightly more abstract judgments involving a mental number line or the size of known or novel objects, where size is what Moyer (1973) proposes is a "salient property of objects." However, the comparisons we make through language need not have direct visual representations and can compare entities or groups along (possibly infinitely many) scales. One might expect that congruity effects might be common in language - that the match between the entities being compared and the scalar adjective used in comparison might affect the speed and/or accuracy with which the comparison is computed. Likewise, it could be the case that distance effects exist in language comprehension as well, even for scales that are more subjective than physical size or brightness. Keeping in mind effects that have been found in non-linguistic (or not primarily linguistic) studies of comparison when studying the processing of degrees will be important in discovering the underlying sources of complexity in comprehending comparatives and related structures.

1.4 The role of implicit prosody in reading

The studies presented in this dissertation all involve visual presentation of linguistic stimuli. While reading adds a secondary task to language processing, a multitude of previous studies in psycholinguistics have shown that reading time measures can be sensitive to events in sentence processing. However, even in reading tasks there are aspects of speech that cannot be ignored. Implicit prosody, or the prosodic representation that is hypothesized to be built incrementally during sentence reading, has been shown to interact with syntactic parsing, for example in ambiguity resolution, as hypothesized by Fodor (1998, 2002a,b), shown in (49).

(49) *Implicit Prosody Hypothesis* (Fodor, 2002b)

In silent reading, a default prosodic contour is projected onto the stimulus, and it may influence syntactic ambiguity resolution. Other things being equal, the parser favors the syntactic analysis associated with the most natural (default) prosodic contour for the construction.

Fodor (2002b) provides evidence supporting the Implicit Prosody Hypothesis from a cross-linguistic study of relative clause attachment ambiguities. For example, Fodor cites Cuetos and Mitchell (1988), who find that relative clause attachment preferences in Spanish appear to violate the principle of Late Closure (Frazier, 1978). In English, ambiguous relative clauses are preferentially attached low creating a preference for *who was on the balcony* to modify *actress* in (50a), while the opposite appears to be true for Spanish (and other languages), as shown by a preference for *que estaba en el balcón* to modify *criada ('servant').*

(50) Fodor (2002b): 2

a. Someone shot the servant of the actress [who was on the balcony].

b. Alguien disparó contra la criada de la actriz [que estaba en el balcón].

Fodor proposes that the reason for the high-attachment preference is a prosodic one: that Spanish and languages with similar attachment preferences favour a prosodic break prior to a relative clause. For Spanish in particular, this preference for a break happens only when the relative clause is fairly long, leading to a diminished high-attachment preference for short relatives.

Further evidence for the important role of implicit prosody in sentence processing comes from the literature on reanalysis. Bader (1998) proposes that reanalysis of an erroneous parse is difficult when the prosodic representation must be modified as well. For example, parsing principles predict that in the examples in each of (51) and (52), the DPs following the verbs *help* and *knew* should be initially parsed as a direct object. However, in each of the (b) examples, this DP (*the little boy* or *the answer*) turns out to be the subject of a clause, requiring reanalysis in order to form the correct syntactic structure for the sentence. The Prosodic Constraint on Reanalysis predicts the intuition that the reanalysis required in (51b) is much more difficult than that required for (52b), because only in

(51b) does the prosodic representation under construction have to be revised. Bader provides further empirical support for the Prosodic Constraint on Reanalysis from several self-paced reading studies in German.

(51) Bader (1998): 1

a. In order to help the little boy Jill put down the package she was carrying.

b. In order to help the little boy put down the package he was carrying.

(52) Bader (1998): 2

a. Peter knew the answer immediately.

b. Peter knew the answer would be false.

While to my knowledge there is little to no work on the prosody of comparative constructions, there are several assumptions we can make based on their similarity to other constructions. The first is that the prosody of a sentence containing comparative is likely to depend on whether a *than*-phrase is present and if one is present, how much clausal material it contains (a bare NP in (53-54) vs. a clause containing a gap in (55-56) and its linear ordering with respect to the rest of the sentence (what I call *base* position in (53, 55) vs. *extraposed* position in (54, 56)).

(53) More dogs *than cats* played fetch.

(54) More dogs played fetch *than cats*.

(55) More people *than the police arrested* were involved in the crime.

(56) More people were involved in the crime *than the police arrested*.

One might also imagine that prosody can help comprehenders to find parallelism between the standard and associate of comparison in order to determine what is being compared (in other words, which argument in the sentence carries the degree variable. This type of effect has been previously shown for gapping (Carlson, 2002). For instance, the structure of the *than*-phrases in (57) and (58) would be foreshadowed by the accent, or *focus*, placed on previous elements.

(57) I spoke to more people at the PARTY than at the OFFICE.

(58) I spoke to more WOMEN at the party than MEN.

In Chapters 2-4, I discuss comparatives with *than*-phrases in *base* position, which precede the main VP of the sentence. In these cases, assigning a prosodic representation to the *than*-phrase may be difficult, because it is not yet clear in the sentence what is being compared. This information is used in a proposal in Chapter 3 by Bhatt and Takahashi (2011b). While my conclusion is that this difficulty is not the sole underlying source of the empirical patterns observed in the acceptability and processing of comparative clauses, it is certainly a factor that deserves further study.

1.5 Outline of the Dissertation

1.5.1 Chapter 2: Garden paths in comparatives

Chapter 2 addresses the expectations that readers have about upcoming structure during the incremental processing of comparatives. In particular, the chapter deals with a curious pattern of acceptability of *than*-clauses in English observed by Osborne (2009). I will show that much of the pattern can be predicted using independently-motivated principles of sentence processing (including those introduced in Section 1.2), and therefore that no new grammatical machinery needs to be added to our theory of the syntax of comparatives in order to account for Osborne's observation.

1.5.2 Chapter 3: Gaps in comparative clauses

Chapter 3 continues the focus on the influence of syntactic properties of comparatives on their processing profiles. I will present experimental data showing a penalty for subject-position gaps in comparative clauses as compared to object gaps. This penalty is unexpected given the opposite pattern that has been found over and over in the psycholinguistic literature for relative clauses, which are superficially similar to comparative clauses. This chapter will give an empirical picture of the subject gap penalty, and show that none of the accounts of processing complexity in relative clauses could predict this reverse result for comparative clauses. Two alternative accounts are discussed in this chapter, one based on Focus Resolution (as per Bhatt and Takahashi, 2011b) and one based on a 'bottleneck' in sentence processing. Neither provides a satisfying theory of the processing difficulty for subject gaps in comparative clauses.

1.5.3 Chapter 4: Island violations and the subject gap penalty

Chapter 4 presents an account of the observations in Chapter 3 based on a subject island constraint violation that is present in comparatives, but not in relative clauses. New data from English and preliminary evidence from Japanese rule out competing analyses, lending additional support to the island violation account. Further support for the subject island violation account is its compatibility with a theoretical proposal for comparatives in Slavic by Pancheva (2010); Pancheva and Tomaszewicz (2010).

1.5.4 Chapter 5: Subset comparatives

Chapter 5 examines a type of comparative that has not received attention in the comparatives literature. I call these comparatives *subset comparatives*. The chapter includes a hypothesis as to an appropriate theoretical analysis of subset comparatives, and also uses these cases to test readers' expectations about the relationship between sets in comparatives during on-line sentence processing.

1.5.5 Chapter 6: Cardinalities and Degrees

Chapter 6 examines the processing of comparisons of plural sets. The chapter presents an eye-tracking experiment showing that comparing plural sets along an adjectival scale, described for example by *heavy*, *tall* or *expensive* involves more cognitive complexity than comparing the cardinalities of plural sets. The results presented in the chapter show that a difference in the cognitive operations that must be performed in order to comprehend a comparative (perhaps even at a level beyond the compositional-semantic representation) can show up during on-line sentence processing.

1.6 Data sources and data analysis

The experimental methods in this dissertation include'off-line' questionnaire studies (rating scale and forced-choice) as well as on-line studies of the timecourse of processing including self-paced reading and eyetracking experiments. The effects were analyzed statistically using linear mixed-effects models using the R environment for statistical computing (R Development Core Team, 2012). The models included fixed effects (centered) for the experimental factors, and random intercepts and slopes to the extent possible (see Barr et al., in press). The experiments are mainly in English, although Chapter 4 presents pilot results from a study in Japanese. As mentioned in

Section 1.1.3, comparatives vary widely in their form across languages. Modeling these variations, I would argue, would benefit greatly from future cross-language experimental research. While experimental data is essential to an investigation into language comprehension, I also hope to bring together various sources of linguistic data, including typological facts and intuitions of sentence acceptability in addition to formal experimental studies.

CHAPTER 2

GARDEN PATHS IN COMPARATIVES

2.1 Introduction

This chapter presents an argument that, for some comparatives, the appearance of ungrammaticality actually reflects *unparsable grammaticality*. In other words, a grammatical sentence (so-called because it can be generated by our internal grammar) can be deemed 'ungrammatical' when factors make it impossible for the parser to arrive at a well-formed representation. The comparatives in question are those with comparative clauses in *base* (non-extraposed) position. Previous analyses have sought a grammatical basis for the curious pattern of acceptability in such comparatives (Osborne, 2009; Pinkham, 1985; Hendriks, 1995). However, because current theories of the syntax and semantics of comparatives (e.g. Kennedy, 1997; Bhatt and Pancheva, 2004) do not provide a means to distinguish between acceptable and unacceptable comparative clauses in base position, such an account would have to introduce undesirable extra machinery into our theory of the structure of comparatives. The unparsable grammaticality account refers to independently motivated principles of sentence processing to predict the pattern of acceptability. I claim that for some comparative clauses in base position, a parsing preference for an NP complement to *than* rather than a clausal complement leads readers to an erroneous parse of the sentence, creating a garden path effect when disambiguating information is encountered. Data from a study of eye movements during reading are presented to support this claim. Further, unlike other garden path sentences that can be reanalyzed successfully with varying amounts of processing cost, reanalysis is extremely unlikely to be successful with the examples in question. The idea that our grammar can generate sentences that are unparsable is not new (Frazier, 1985; Chomsky and Miller, 1963; Bever, 1970a; Bever and Langendoen, 1971). The present account shows that unparsable grammaticality provides the most parsimonious account of a new data set, and also refines the notion of unparsable grammaticality in general.

2.2 Unparsable Grammaticality

The distinction between competence and performance in language is a founding principle of generative linguistics (e.g., Chomsky, 1965). The classic example of a conflict between generative grammar and our resources for comprehending language is doubly center-embedded sentences, as shown in (59a, from Bever, 1974). These sentences show comprehension difficulty in comparison to equivalent right-branching structures like (59b) (e.g., Blaubergs and Braine, 1974). Chomsky and Miller (1963) (see also Bever, 1970b) claimed that it is a limitation on human memory that impedes comprehension of doubly center-embedded sentences like (59a, compared to 59b), rather than a constraint on recursion in the grammar.

(59) a. # The man the boy the girl likes saw kicked the dog.[1] (Bever, 1974: 4)

b. The girl likes the boy who saw the man who kicked the dog.

Further support for the claim that the degraded status of (59a) has a source outside of grammar comes from evidence that showing that the discourse properties of the nouns in center-embedded sentences can affect comprehension difficulty (Gibson, 2000; Warren and Gibson, 2002). For example, Warren and Gibson (2002) show that (60a), which has a pronoun as the most embedded subject, was rated as less complex than (60b), which has all definite DP subjects. the constraint against doubly center-embedded sentences were in the grammar, we would not expect native speaker judgments to be susceptible to changes in the form of the DPs in a sentence.[2]

(60) Warren and Gibson (2002): 6

a. The student who the professor who I collaborated with had advised copied the article.

b. The student who the professor who the scientist collaborated with had advised copied the article.

In addition to memory limitations on sentence processing, parsing principles have been claimed to cause the appearance of ungrammaticality in some sentences. While garden path sentences like

[1]Throughout the chapter, I will use # to mark sentences that are degraded due to factors other than generative syntax.

[2]I assume that it is possible for grammatical constraint to have a processing source. However, as argued by Häussler et al. (under review), a constraint that is a part of the grammar should be de-coupled from its processing source if it has one.

(61a) are very difficult to process, it is possible to eliminate the ambiguity (and therefore the garden path effect) by substituting unambiguous lexical items (61b). However, in some cases it is impossible to substitute lexical items to eliminate a garden path. For example, there are no substitutions that would eliminate the garden path effects in (62a) and (62c).

(61) a. The horse raced past the barn fell.

b. The horse *ridden* past the barn fell.

(62) Frazier (1985: 9-10)

a. # The man entered tripped.

b. The man who entered tripped.

c. # It is sunny upsets the pessimists.

d. That it is sunny upsets the pessimists.

Frazier (1985), following Bever (1970a) and Bever and Langendoen (1971), proposed that (the appearance of) ungrammaticality can result when sentences invariably produce a garden path, regardless of their lexical content. The resulting *Impermissible Ambiguity Constraint* is shown in (63).

(63) *Impermissible Ambiguity Constraint* (Frazier, 1985):

Languages prohibit constructions containing a clause that is misanalyzed the same way every time it occurs regardless of the particular words in the clause.

Frazier notes that the Impermissible Ambiguity Constraint can account for the requirement for a relative pronoun in subject relative clauses[3] which is violated in (62a). Because past-tense verbs in matrix and relative clauses have the same form, there is no verb that could be substituted for *entered* that would disambiguate toward a relative clause. Therefore, a relative pronoun must be present in this construction (62b) to avoid the tempting matrix clause analysis of the relative clause verb. Impermissible Ambiguity can also account for the requirement for a complementizer *that*

[3]Although, some dialects do allow subject relative clauses without *that/who* in limited environments; see Doherty (1993) for a discussion of their distribution.

in sentential subjects (62c). Without the complementizer *that*, the subject clause will always be mistakenly processed as a main clause, causing a garden path.

The condition in the Impermissible Ambiguity Constraint that no possible lexical substitutions can prevent misanalysis prevents the constraint from erroneously ruling out other temporarily ambiguous sentences. For example, Exceptional Case Marking structures like (64a) contain a garden path, but because substituting the verb *believe* for one that does not typically take a pronominal object (*assume* in 64b) would eliminate the garden path reading, (64a) is not an example of Impermissible Ambiguity.

(64) a. I believed him to be innocent.

b. I *assumed* him to be innocent.

Impermissibly ambiguous sentences have been argued to be “prohibited" by languages, but it is important to think about the level at which this prohibition occurs. These sentences arguably have a status that I will call unparsable grammaticality; in other words, like doubly center-embedded sentences, our grammar is able to generate sentences that are impermissibly ambiguous, but our comprehension system is unable to parse them.

In this chapter, I will discuss data from comparatives and claim that these data support a third kind of grammatical, but unparsable, sentence. These are cases where there is a strong garden path, and no strategies for reanalysis are able to help the comprehender reach a well-formed representation of the sentence. In English comparatives, the standard of comparison marked by *than* (also called the comparative clause (Bresnan, 1973) or *than*-clause when the the constituent headed by *than* is clausal) may vary in its linear ordering with respect to other constituents. For example, the comparative clause in (65a), modified from Pinkham (1982), is in what I will call *extraposed* position (although I assume, following Bhatt and Pancheva (2004), that comparative clauses are merged late in their surface positions), while in (65b) the comparative clause is in *base* position, next to the associate of comparison *more people*.

(65) a. More people came to the party **than we invited**.

b. More people **than we invited** came to the party.

However, as Osborne (2009) observes, the distribution of comparative clauses in base position is more restricted than that of extraposed position. In (66), extraposed order (66a) is relatively acceptable, while base order (66b) is severely degraded.

(66) Modified from Osborne (2009): 2

a. More boys ordered salad **than girls ordered steak.**

b. *?/# More boys **than girls ordered steak** ordered salad.

Osborne cites a reviewer's suggestion that the degraded examples of comparative clauses in base position all cause a garden path effect, but nonetheless gives a grammatical account of the pattern of data (I will return to Osborne's account in Section 2.8.1). I will argue that the garden path created by these examples, and its consequences, are all that is needed to predict the pattern of acceptability in (65-66). The pattern can be accounted for by independently motivated principles of sentence processing and does not require a grammatical explanation.

Examples like (66b) do not fall under the umbrella of Impermissible Ambiguity; example (65b) shows that if the subject of the comparative clause is replaced with an unambiguously nominative pronoun subject, a comparative clause is acceptable in base position. Therefore, a different explanation of how a severe garden path can lead to unacceptability is required. The analysis presented here will proceed as follows. In Section 2.3, I will motivate the analysis by showing that currently accepted theories of syntax and semantics do not predict a difference between examples like (65b) and (66b). I will then make precise in Section 2.4 the structure that readers initially (and erroneously) adopt when attempting to process sentences like (66b). In Section 2.5, I will lay out the claim that it is the garden path effect due to this initial erroneous reading that causes the difficulty with some comparative clauses in base position. A study of eye movements during reading will then be presented as experimental evidence that a garden path occurs in examples like (66b) in Section 2.6. In Section 2.7, I will show that the unacceptability of examples like (66b) results because none of the mechanisms our parser has been claimed to have to overcome garden path effects will help to produce a well-formed parse of examples like (66b).

2.3 Why the pattern is a puzzle for current theories

In Chapter 1, I outlined a framework for the syntax and semantics of comparatives (the standard analysis of comparatives, updated by Bhatt and Pancheva). In this framework, the position of the *than*-clause is determined by the scope of the degree quantifier that contains it. An alternative account by Kennedy (1999) also account holds *than*-clauses have positions related to their scope. While these two types of accounts make different assumptions about the semantic type of a *than*-clause (a function from degrees to truth values or a degree, respectively), crucially neither proposes that the internal contents of the *than*-clause plays a role in where it can appear in the linear order of the sentence.[4] Therefore, these theories do not predict any difference in acceptability between (65) and (66), repeated as (67-68).

(67) a. More people came to the party **than we invited**.

b. More people **than we invited** came to the party.

(68) Modified from Osborne (2009): 2

a. More boys ordered salad **than girls ordered steak.**

b. *?/# More boys **than girls ordered steak** ordered salad.

The inability of current accounts to capture the difference between (67) and (68) leaves researchers with the decision of whether to amend our theory of comparatives to reference the internal contents of the *than*-clause in determining its surface position (the position taken by Osborne, 2009), or to look for an explanation of the pattern of acceptability of *than*-clauses in base position outside of our theory of syntax and compositional semantics. Here, I will take the latter option. In Section 2.5, I will develop an account of this pattern of acceptability that does not require a change in our theory of the syntax and semantics of comparatives. Osborne (2009) notes that a reviewer mentions that degraded comparative clauses in base position all give the impression of leading the reader down a 'garden path.' I will argue that it is indeed this garden path effect that leads to the degraded status of these examples, and in Section 2.6 provide experimental evidence in support of this claim. I will return to Osborne's analysis in Section 2.8.1, and compare its predictions to those

[4]With the exception that reduction operations like ellipsis and gapping must in general precede the site of deletion (Lechner, 2001, 2004), and so *than*-clauses on which these reduction operations have applied must follow the constituent containing the antecedent.

of the processing account. Before developing the present analysis, however, I will motivate a theoretical assumption that there is a special structure for so-called DP-internal subcomparatives. This special structure is the attractive, but ultimately erroneous, representation that leads to the garden path effect in (66b).

2.4 More (than) as a two-place determiner

Up to this point I have discussed examples that clearly contain a clausal complement to *than*. Examples such as (69) pose a problem for theories positing that *than*-clauses are all underlyingly clausal (e.g., Lechner, 2001, 2004). These examples have a bare plural complement to *than* with nothing intervening between the associate of comparison (*boys*) and the *than*-phrase. In these cases, full-DP complements to *than* are not licensed, as shown in (70).[5]

(69) More boys than girls drink soda.

(70) * More boys than a/the girl drink soda.

Further, modifiers above the level of NP seem not to be licensed with these kinds of structures. *as many/much as*) as a determiner that takes two NP predicates as arguments, providing the comparison between them as a part of its meaning.

(71) *? More girls **than boys yesterday** drank soda today.

The restrictions on the complement to *than* in these kinds of examples indicates that they have underlying structures that are different from other kinds of comparatives. Keenan (1987) analyzes examples like (69) as multiply-headed NPs, where *more* is analyzed as a two-place determiner that takes two NP arguments (and a third VP argument). This approach does not take the determiner *more* to be composed of *many* + *er* as proposed by Bresnan (1973). Instead, *more than* would be a determiner of type $< et < et < et\ t >>>$, which does not introduce degrees into the semantics.

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[5]This is true unless the complement to *than* is understood to be a subset of the associate of the comparative, for example in (i). See Grant (to appear) for an analysis of these so-called *subset comparatives*.

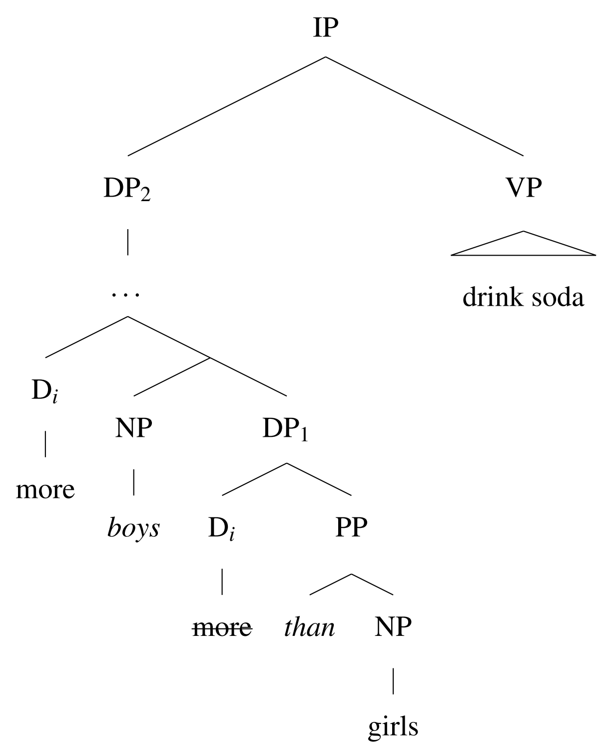
i. More birds than (just) an eagle flew over the conservation area.

In what follows I will assume that the determiner meaning is introduced by *more*, which selects for a constituent headed by a semantically vacuous *than*. The semantics for *more* as a two-place determiner that I will use is shown in (72).

(72) $[[\textit{more (than)}]] = \lambda Z_{et}.\ \lambda Q_{et}\ .\lambda P_{et}|x:\ Q(x)\ \&\ P(x)|\ >\ |x:\ Z(x)\ \&\ P(x)|$

While the semantics for the two-place determiner shown above provides the intuitive meaning of *more* in contexts like (69), the syntactic structure presented in Keenan (1987) involves non-binary branching. However, a way of mapping Keenan's idea of the semantics of comparatives onto a binary-branching syntactic structure is provided by Izvorski (1995a). Building on Keenan's comparative determiner analysis, Izvorski (1995a) proposes a syntax for comparatives like (69) using a DP-shell structure (parallel to that proposed by Larson (1988) for double object constructions). This structure for (69) is shown in (240). Izvorski treats *than* as a preposition, and follows Keenan's claim that *more* (or *fewer*, etc.) is a two-place determiner.

(73)



The DP shell structure includes movement of the two-place determiner from an embedded DP (DP_1) to a higher DP (DP_2). This movement allows the two-place determiner to take both the than-expression and the associate NP as complements at the different points of the structure. The lower DP position accounts for selectional restrictions between the determiner and the preposition. The determiners *more* and *fewer* select for *than*, while *as many/much* selects for *as*, as shown in (74). The higher DP position accounts for selectional restrictions on the associate NP, which can only be a bare NP that does not have a determiner. This restriction is illustrated in (75).

(74) a. More/fewer boys than/*as girls drink soda.

b. As many boys as/*than girls drink soda.

(75) More (*the/*some/*two) boys than girls drink soda.

The desired meaning for the subject position comparative that simply compares cardinalities, given in (72), can be mapped fairly transparently onto the DP-shell structure by assuming that the semantic interpretation of the determiner occurs in its lower position. While Izvorski does not limit the DP-shell structure to the cases like (69), I will assume that this structure is only available for examples that compare cardinalities or amounts. Other comparatives have the structure and semantics described by the standard approach. In the next section, I will introduce an analysis of the difficulty associated with than-expressions in base position based on syntactic and semantic parsing. One key component of this analysis is that a two-place determiner meaning for *more, fewer* and *as many* exists (at least for English), and this is the meaning that is understood in examples like (69).

2.5 Garden Paths in Comparatives

In this section, I will claim that the pattern of acceptability of *than*-clauses in base position can be predicted using principles of parsing and reanalysis, without adding constraints to our syntax or semantics. First, consider examples like (66b), repeated as (76). Up to the point of *steak*, (76) is ambiguous between a two-place determiner interpretation (shown in 77a) and a standard comparative (77b) with a full clause *than*-clause. When the sentence is concluded with material that would disambiguate toward the standard comparative (meaning something like "the number of boys who ordered salad is greater than the number of girls who ordered steak"), it is at least extremely degraded in acceptability, if not ungrammatical.

(76) *? More boys **than girls ordered steak** ordered salad.

(77) a. [[$_{DP}$More boys **than girls**] [$_{VP}$ ordered steak]]

b. [[$_{DP}$More boys **than girls ordered steak**] [$_{VP}$ ordered salad]]

The analysis I will offer holds that (76) is not ungrammatical (i.e., our grammar can generate such a sentence), but that it is essentially unparsable due to processing difficulty from a convergence of sources. I claim that the parser has a preference for the two-place determiner interpretation of (76), and initially takes *girls* to be an NP complement to *than*, and *ordered steak* as the main VP.[6] Upon encountering the second VP (*ordered salad*), the parser experiences a syntactic/semantic 'garden path' effect. As a result, the parser is faced with a difficult reanalysis task that is prone to failure. The only possible parse of the entire sentence, shown in (77b), is never achieved, and therefore the sentence gives the impression of ungrammaticality.

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[6] Crucially, the preference for an NP complement to *than* is at least less present in extraposed position. Example (i) does not intuitively suffer from the same garden path effect I have claimed for (76).

i. More boys ordered salad than girls ordered steak.

There are two reasons why the garden path effect does not occur with *than*-clauses in extraposed position. The first is that the semantics of the two-place determiner *more* do not allow for extraposition; with this word order, a compositional failure would occur. Therefore, all extraposed comparative clauses must be analyzed as standard comparatives with degree abstraction, and this difference could be driving the asymmetry between base and extraposed positions. Further, it is possible that the decreased preference for an NP complement to *than* (and therefore the lack of garden path) in extraposed position is be prosodic in nature. Fodor (1998) proposes that attachment preferences are prosodically guided, and that new constituents at the right edge of the structure being parsed are preferentially attached to a constituent of equal size (the *same size sister constraint*). Fodor uses as an example the preference for (ii-a) to be interpreted as the daughter of the divorced bishop, while in (ii-b), the prosodic same size sister constraint pushes toward the interpretation that it is the bishop's daughter that is divorced, as indicated by brackets.

ii. Fodor (1998):18-19
  a. The [divorced bishop's] [daughter]
  b. The [recently divorced] [bishop's daughter]

The same size sister constraint could be at play in comparatives in driving a preference for an NP complement to *than* in the base position cases, but a clausal complement in the extraposed cases, where the main VP could serve as a prosodic sister. In (iii-a), *colleagues* finds a same size sister in *friends*. However, the bracketed potential sisters in (iii-b) are not of equal sizes. If a balanced prosodic sister is selected, as in (iii-c), an infelicitous interpretation is suggested wherein *party* and *colleagues* are being compared.

iii. a. More [friends] than [colleagues] went to the party.
  b. More friends [went to the party] than [colleagues].
  c. More friends went to the [party] than [colleagues].

The preference for a two-place *more* in (iv-a) creates an expectation for an NP complement to *than* that is later disconfirmed. However, potentially because of the same size sister constraint, there is an expectation for a clausal complement to *than* in (iv-b), making the sentence relatively acceptable. This type of structure is discussed further in Section 2.8.3.

iv. a. # More [friends] than [neighbours] went to the park went to the party.
  b. More [friends went to the party] than [neighbours went to the park].

Before turning to the reanalysis task that would be required to achieve a grammatical parse for (76), I will provide empirical evidence from a study of eye movements during reading to support the claim that the two-place determiner interpretation is the one the parser adopts first.

2.6 Experiment 1

The preference for the two-place determiner interpretation of *more NP than NP*, and the resulting garden path upon encountering evidence for a clausal *than*-clause, requires empirical support if the garden path analysis is to be maintained. To test whether readers experience this garden path, a study of eye movements during reading was carried out. If readers experience a garden path when a bare plural follows *than*, as in (78a), then they should experience difficulty with the second VP (*cared..*). When the NP/DP following *than* signals that the two-place determiner is unavailable, as in (78b), there may be a processing difficulty associated with revising to a comparative clause interpretation. However, this disambiguation should mitigate the garden path effect on later regions predicted for sentences like (78a). In this experiment, relative clauses with subject and object gaps were used as controls for the comparative conditions. This comparison was made in order to tease apart any difficulty that results from the garden path caused by a bare plural following *than* from difficulty attributable to having a bare plural subject of an embedded clause as opposed to a proper name. Example (78c) has a bare plural subject of a relative clause, but no ambiguity and therefore no possibility of a garden path. Gordon et al. (2004) found that bare plural (generic) NPs were less frequent as the subjects of object relative clauses than definite DPs in a search of three corpora. However, there was not a significant additional cost for bare plurals in object relative clauses as compared to subject relative clauses in a self-paced reading task (although there was a numerical interaction of this type on the region comprising the entire relative clause after the relativizer). Nonetheless, relative clauses are effective controls for this experiment. If, contrary to predictions, subjects are able to immediately take the NP following *than* as the subject of a comparative clause (and therefore not experience a garden path effect), then any processing difficulty associated with bare plural subjects should be equal for relative clauses comparative clauses.

(78) Example item set (| delimits analysis regions)

a. More nurses$_{1}$| than$_{2}$| patients$_{3}$| thanked$_{4}$| cared$_{5}$| a great deal about their jobs.$_{6}$|

b. More nurses$_{1}$| than$_{2}$| Percival$_{3}$| thanked$_{4}$| cared$_{5}$| a great deal about their jobs.$_{6}$|

c. The nurses$_{1}$| that$_{2}$| patients$_{3}$| thanked$_{4}$| cared$_{5}$| a great deal about their jobs.$_{6}$|

d. The nurses$_{1}$| that$_{2}$| Percival$_{3}$| thanked$_{4}$| cared$_{5}$| a great deal about their jobs. $_{6}$|

2.6.1 Methods

2.6.1.0.1 ***Materials*** Twenty-four item sets like the one in (78) were constructed. The experiment manipulated two variables. The first variable that was manipulated was whether or not the two-place determiner was licensed for the NP/DP immediately following *than* (NP Type). This NP/DP was either a bare plural, as in (78a), or a proper name, as in (78b). Proper names are not licensed under the two-place determiner interpretation, and must therefore be parsed as the subject of a clausal *than*-clause.[7] Second, the comparatives (78a) and (78b) were compared to corresponding relative clause items (Sentence Type). Half of the relative clause materials used the relativizer *that* and half used *who*. In order to increase overall acceptability and to keep the comparative clauses parallel to relative clauses, which must contain a DP gap, the comparative clauses and relative clauses all had gaps in object position. The full list of experimental materials is found in Appendix A. The experimental items were counterbalanced across four lists, and intermixed with 130 distractor items from unrelated experiments. Some of these distractor items also contained relative clauses, but none contained comparatives.

2.6.1.0.2 ***Procedure*** Twenty-four UMass Undergraduates participated individually. All subjects were native speakers of English and were naive to the purpose of the experiment. Subjects received psychology course credit for participation. The experiment was run on an Eyelink 1000 eyetracker (SR Research) interfaced with a PC. Viewing was binocular, but only the movements of the right eye were monitored. Subjects were seated at 60cm from the computer screen. At this distance, 3.82 characters subtended 1° of visual angle on average. After an initial calibration phase, subjects triggered each sentence to appear with an eye movement to a trigger box on the lefthand side of the

[7]The proper names were chosen to so as to dissuade readers from the subset comparative meaning (see Grant, to appear), using gender or titles (Dr., Mr.). See the appendix for the full list of experimental materials.

computer screen. Subjects were instructed to read naturally for comprehension. After 50% of trials, subjects were presented with a two-choice comprehension question, which they answered with a button press.

2.6.2 Results

2.6.2.0.3 ***Eye movement data*** In analyzing the results of the experiment, several measures of eye movements during reading were computed (see Staub and Rayner (2007) for further discussion of eye movement measures). *First-Pass Time* is the sum of all fixations on a region from first entering the region until leaving it, either to the left or the right, for the first time. *Go-Past Time* (also sometimes called *regression path duration*) is the sum of all fixations from first entering a region until leaving it to the right, including any re-reading time on earlier parts of the sentence. The proportion of *Regressions Out* presents the proportion of trials on which there was a leftward eye movement out of the first pass of a region. Finally, *Regressions In* measures the proportion of trials on which at least one fixation in a region was preceded by a fixation to the right of that region. The means and standard errors for all measures on each region are presented in Table 1. In the text of this section, I will discuss the important results from the material following *than* or the relative pronoun (*that/who*), which makes up Regions 3-6. The data were fitted with linear mixed-effects models (Baayen, 2008; Baayen et al., 2008) using the lme4 package (Bates, 2005) in R (R Development Core Team, 2012). The models included fixed effects of Sentence Type, NP Type and their interaction. Trial order was added as to all models as a continuous fixed effect to ensure that no spurious effects were found that were related to subjects' habituation to the materials over the course of the experiment. All predictors were centered prior to statistical analysis. All models included random intercepts for Subjects and Items as well as random slopes for Sentence Type, NP Type and their interaction. Because there is currently no implementation of a p-value generating function in R for models with random slopes, no p-values are given. Instead, t values above 2 or below -2 are interpreted as significant. Summaries of model parameters for all analyses on the regions of interest are shown in Appendix B.

The results of interest pertain to two main predictions. The first prediction is that, in comparatives, readers would take a bare plural following *than* to be an NP complement following the two-place determiner meaning discussed in Section 2.4. This prediction is borne out in the experimental data. The first place this result is evident is in Go-Past Time on Region 3 (the bare plural or proper name). This region showed a marginally significant interaction between Sentence Type and NP Type (Estimate = -151, SE = 78.7, t = -1.93). This interaction was such that bare plurals in comparatives had shorter Go-Past Times than proper names, while bare plurals had longer Go-Past Times than proper names in relative clauses. On the embedded verb, Region 4, the same interaction pattern was fully significant (Estimate = -298, SE = 93.5, t = -3.19). The advantage for bare plurals in comparatives was still significant when only the comparative conditions were considered (t = -2.03). In Regressions Out, there was an effect in Region 4 of Sentence Type (Estimate = -0.84, SE = .33, z = -2.51, p = .01), and a significant interaction (-2.70, SE = .67, z = -4.02, p <.001) such that the bare plural/relative clause condition was associated with more regressions than relative clauses with proper name subjects, but the reverse numerical pattern held for comparatives. The full pattern of Regressions Out is shown in the lefthand panel of Figure 1. Together, these effects show that the bare plural following *than* was not interpreted as the subject of a comparative clause, but rather was taken to be a confirmation of the expectation for a two-place determiner *more (than)*.

The second prediction of interest is that, in the bare plural comparative condition, readers would experience a garden path effect when the two-place determiner interpretation is shown to be impossible (at the point of the true main verb). This prediction is also borne out by the data, although the effect appeared on the final region of the sentence rather than on the main verb itself. In First Pass Time, the final region of the sentence (Region 6) showed an effect of Sentence Type (Estimate = -145.60, SE = 40.92, t = -3.56), a significant effect of NP Type (Estimate = -90.78, SE = 36.74, t = -2.47) and a trend toward an interaction between the two factors (Estimate = -151.44, SE = 78.68, t = -1.87), such that the comparatives with bare plural NPs following than actually had the *shortest* First Pass Times on this region. This result came about due to a large number of regressive eye movements from that region in the bare plural/comparative condition. On Region 6 there was an effect of sentence type (Estimate = .91, SE = .27, z = 3.41, p < 0.001), an effect of NP Type (Estimate = .79, SE = .33, z = 2.39, p < .05) and also a significant interaction (Estimate = 1.12, SE = .53, z = 2.12, p < .05) such that there were more Regressions Out for comparatives as opposed to relative clauses, and that the bare plural condition had a higher percentage of regressions than the proper name condition. This interaction was also reflected numerically in Go-Past Time for the final region, although only the effects of Sentence Type (Estimate = 439.49, SE = 117.44, t = 3.74), and NP Type (Estimate = 307.31, SE = 49.63, t = 2.34) reached significance.

While the garden path effect for comparative clauses with bare plural subjects was apparent on the final region of the sentence, the results on the main verb region itself (Region 5) were unexpected. On Region 5, there was an effect of Sentence Type, with more regressions for comparatives than for relative clauses (Estimate = 1.40, SE = .35, z = 4.00, p < .001), and an interaction such that comparatives with proper names had the most regressions (Estimate = -1.80, SE = .74, z = -2.44, p = .01)[8]. The increase in Regressions Out of the comparative/proper name condition on the main verb could reflect a cost for disambiguation toward the dispreferred clausal *than*-complement.

Because of the large number of regressive eye movements found from the final region (over 60% from the bare plural/comparative condition), the measure of Regressions In was also computed in order to determine what regions these regressions targeted. The righthand panel of Figure 1 shows the full pattern of Regressions In. Region 5 showed an increase in Regressions In for comparatives as opposed to relative clauses (Estimate = 0.79, SE = .31, z = -2.51 p = .01), a marginal effect of NP Type such that there were more Regressions In in the bare plural conditions (Estimate = .54, SE = .29, z = 1.82, p = .07), and a marginal interaction such that the greatest proportion of trials with regressions into this region were for bare plural comparatives (Estimate = 1.07, SE = .62, z = 1.74, p = .08). This pattern is distinct from that in Region 4, where there is no hint of an interaction between the two factors (Estimate = .53, SE = .66, z = .803, p = .42). The pattern of Regressions In provides a tentative indication that readers' regressive eye movements were more likely to specifically target Region 5, the disambiguating region, in the comparative/bare plural condition as opposed to bare plural conditions in general.

2.6.2.0.4 ***Comprehension Question Data*** The goal of the comprehension questions was to ensure that subjects attempted to comprehend the sentences in the experiment. Each subject answered three comprehension questions per experimental condition, for a total of twelve questions per subject. The mean comprehension accuracy for sentences in each condition is shown in Table 2. A by-subjects ANOVA showed that there was a significant interaction between Sentence Type and NP

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[8]The interaction in this region only reached significance when random slopes were included in the model.

	Initial Region (1)	*Than/That* (2)	Plural NP/ Proper Name (3)	Embedded Verb (4)	Main Verb (5)	Final Region (6)
First Pass Time (ms)						
Comp., BP	402 (19)	275 (12)	267 (12)	331 (15)	370 (19)	**508 (30)**
Comp., PN	385 (20)	271 (12)	354 (21)	369 (15)	355 (17)	**662 (34)**
Rel., BP	286 (13)	274 (14)	294 (19)	359 (18)	358 (19)	**717 (42)**
Rel., PN	287 (15)	258 (9)	333 (18)	334 (18)	328 (14)	**744 (43)**
Go-Past Time (ms)						
Comp., BP	402 (19)	364 (26)	**396 (32)**	**417 (35)**	595 (54)	**1937 (131)**
Comp., PN	385 (20)	351 (22)	**466 (31)**	**518 (35)**	643 (56)	**1523 (104)**
Rel., BP	286 (13)	348 (31)	**513 (46)**	**645 (54)**	464 (43)	**1375 (94)**
Rel., PN	287 (15)	333 (22)	**447 (26)**	**443 (35)**	406 (29)	**1239 (76)**
Regressions Out (%)						
Comp., BP	NA	15.6 (3.8)	20.6 (4.1)	**8.4 (2.6)**	23.2 (4.0)	**64.3 (4.3)**
Comp., PN	NA	16.5 (4.0)	22.2 (4.2)	**17.7 (3.6)**	31.6 (4.7)	**41.4 (4.6)**
Rel., BP	NA	13.2 (4.1)	27.6 (4.5)	**32.1 (4.6)**	12.1 (3.3)	**38.7 (4.6)**
Rel., PN	NA	18.8 (4.0)	26.2 (4.2)	**13.9 (3.2)**	10.3 (2.9)	**29.4 (4.5)**
Regressions In (%)						
Comp., BP	67.3 (4.7)	36.4 (4.7)	39.7 (4.7)	61.1(4.4)	**46.3 (4.6)**	NA
Comp., PN	66.3 (5.0)	33.6 (4.7)	28.6 (4.3)	42.2 (4.6)	**29.6 (4.4)**	NA
Rel., BP	76.6 (5.3)	43.5 (5.2)	35.2 (4.7)	22.0 (4.0)	**26.2 (4.3)**	NA
Rel., PN	65.0 (6.2)	39.8 (5.1)	18.8 (3.7)	19.7 (3.7)	**24.1 (4.1)**	NA

Table 2.1. Means for eye-movement measures, Experiment 1

Note: NA indicates where a particular measure does not apply to a region (e.g., regressions from the first region of the sentence). Effects discussed in the text of Section 2.6.2 are bolded in the table. Standard Errors are represented in parentheses.

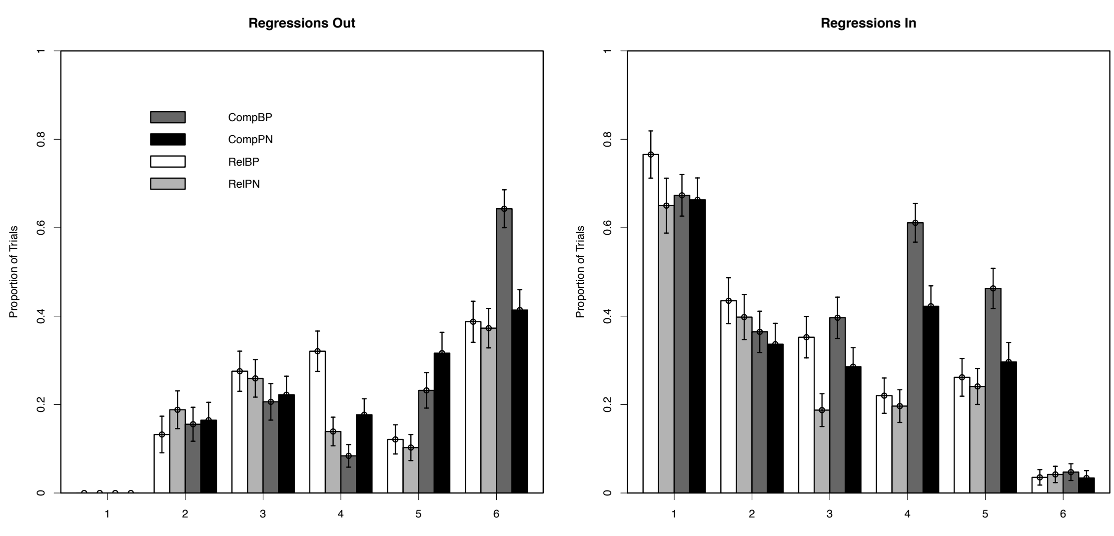


Figure 2.1. Regressions Out and Regressions In by region. Bars indicate standard errors of the mean.

	Bare plural	Proper Name
Comparative	60.0	76.8
Relative Clause	78.9	78.9

Table 2.2. Mean accuracy on comprehension questions.

Type such that the bare plural/comparative condition showed the lowest overall accuracy ($F(1,23) = 6.00$, $p < .05$), as well as a main effect of Sentence Type ($F(1,23) = 5.18$, $p < .05$). Because item-by-item accuracy was not available (and the number of questioned items was very small), the question accuracy data should only be taken as preliminary additional support for subjects' difficulty with the bare plural, comparative condition. No subjects were eliminated from data analysis due to poor performance on comprehension questions.

2.6.3 Discussion

The results of the eyetracking experiment support the claim that readers initially adopt a two-place determiner (and therefore NP-complement to *than*) analysis upon encountering a bare plural NP following *than*. While there was a penalty for having a bare plural subject of a relative clause, as demonstrated in Go-Past Time and Regressions Out of the embedded verb region, bare plural subjects of comparative clauses did not show a similar penalty. This finding suggests that the bare plurals following *than* were not being interpreted as the subject of a comparative clause. Comparatives with proper names had numerically longer Go-Past Times and higher rates of Regressions Out of the embedded verb, signaling that perhaps there is some cost associated with readers encountering disambiguating evidence for a comparative clause when they had predicted a phrasal complement to *than*. The high rates of regressive eye movements out of the final region of the sentence and into the ambiguous and disambiguating verb regions provides evidence of a severe garden path in comparatives with bare plural comparative clause subjects.[9] These are 'late' effects in the

[9]Recent evidence from eyetracking (Levy et al., 2009) has shown that readers' uncertainty about the outcome of word recognition can affect their processing of a sentence. In the experimental sentences tested here, one could imagine that readers might be uncertain that they had truly recognized *than*, which has a high-frequency neighbour *that*. However, readers assuming that they had misrecognized *that* as *than* would predict not predict the observed pattern of results. Note that in the relative clause control conditions, bare plural subjects of relative clauses showed processing difficulty relative to proper names. If readers assumed that they had misinterpreted the sentence and instead assumed that they had seen a

eye movement record, and they provide an indication that readers had not constructed a well-formed analysis of the sentence by the time they read the sentence for the first time. The long Total Times on the final region also suggest that it is possible readers sometimes failed to form an interpretation of the sentence by the time they indicated that they had finished reading.

The experimental data presented here show that there is a garden path effect in comparative clauses with bare plural subjects, and that these sentences make it very difficult for readers to form a licit parse of the sentence during normal reading. However, as mentioned in the description of materials, the experimental sentences (e.g., 79) have not been claimed to be ungrammatical, as have similar cases with an overt object (making a subcomparative, rather than a comparative) (e.g., 80).

(79) More nurses than patients thanked cared a great deal about their jobs.

(80) More nurses than patients thanked volunteers cared a great deal about their jobs.

The next section will begin to address why (80) should achieve an even more degraded status than (79), and the issue will be revisited again in Section 2.8.2.

2.7 Reanalysis and reanalysis failure

The experiment described above supports the claim that readers experience a garden path while reading comparative clauses with bare plural subjects. I have argued that this garden path effect is due to a parsing preference for a two-place determiner *more (than)*, wherein *than* takes an NP complement. However, not all garden path effects cause equal processing difficulty, and not all arise for the same reason. The particular difficulty of examples like (66b) and (80) needs some further explanation.

While classic garden path sentences such as (81) are extremely difficult to process, they are not generally claimed to be ungrammatical.

(81) The horse raced past the barn fell.

This section deals with the questions of why reanalysis is exceedingly difficult (and perhaps impossible) in some examples of comparative clauses in base position, and further why some of

relativizer *that*, we would expect some eye movement measure (e.g., Total Time) to reflect this. This prediction was not borne out in the data.

these examples are perceived to be ungrammatical. Section 2.7.1 shows that the reanalysis task in the experimental examples above is predicted to be extremely difficult. Section 2.7.2 deals with the question of why comparative garden paths lead to reported ungrammaticality, rather than merely extremely difficult processing.

2.7.1 Difficulty of Reanalysis

Sentences very often require the parser to revise the representation it has built at some point during processing. However, not all reanalyses cause the palpable processing difficulty associated with garden path sentences like (81). Psycholinguists have tried to model the differing levels of difficulty with different reanalyses (e.g., articles in Fodor and Ferreira, 1998; Sturt and Crocker, 1996; Sturt et al., 1999, 2002). The proposals for the sources of difficulty can be divided into those that differentiate the structural changes required for easy versus hard reanalyses, and those that rest on the type of evidence indicating that revision is necessary. These will be discussed in turn.

2.7.1.1 Structural Factors

The pattern of eye movements observed in the experiment described above suggests that although intuitively sentences like (82) may be more acceptable than those with an overt object (as in (80), they are difficult to process, and often a well-formed parse of the sentence is not achieved before the reader reaches the final region of the sentence.

(82) More ballerinas **than patrons applauded** performed a beautiful encore.

If the claim that examples like (66b) and (82) show degraded acceptability due to a severe garden path effect, it is important to show why it differs from other garden path cases that are not reduced or only slightly in acceptability, for example the so-called NP/S ambiguity in (83a). Here, the NP *the answer* is temporarily ambiguous between an NP/DP object of the main clause verb *knew*, or the subject of a clausal complement to *knew*. The principle of minimal attachment (Frazier, 1978, 1987b) predicts that readers will initially misparse *the answer* as an NP/DP object, because this analysis is simpler than the clausal complement analysis in terms of the number of syntactic nodes required. This prediction has been borne out repeatedly in the experimental literature (Frazier and Rayner, 1982; Ferreira and Henderson, 1990; Sturt et al., 1999, among many others) through increased reading times for the disambiguating region of (83a) as compared to the same region in the unambiguous (83b).

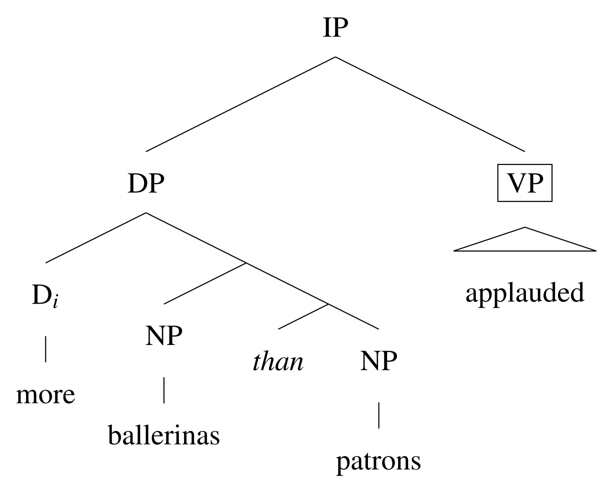
(83) a. The students knew **the answer** was correct.

b. The students knew that the answer was correct.

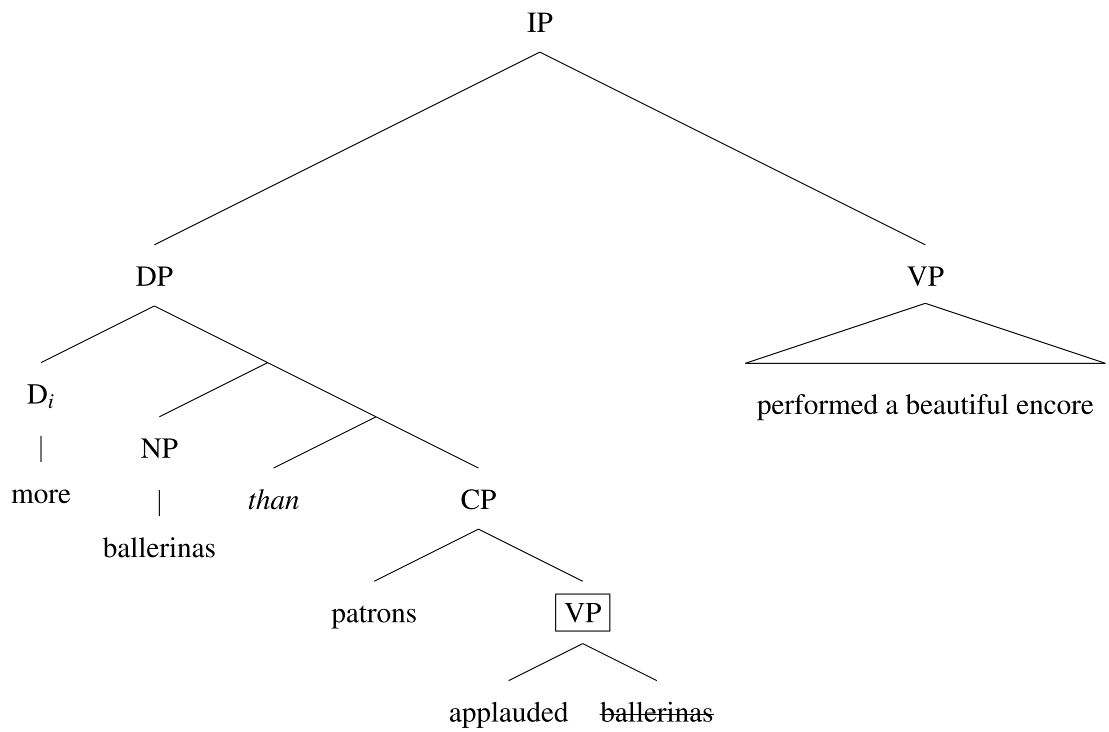
Despite the finding that there is some processing difficulty associated with (83a), the sentence does not have the same processing difficulty associated with other types of garden path sentences. Therefore it is not the presence of just *any* garden path that creates the impression of ungrammaticality. Previous research has examined the question of why some syntactic garden paths are easy to recover from while others are very difficult (e.g., Sturt and Crocker, 1996; Lewis, 1998). The classic example of a main VP/reduced relative clause ambiguity (in 81) is one where even after several minutes, readers may not arrive at well-formed interpretation of the sentence.

I will claim that examples like (82) and (66b) are more like reduced relative garden paths than they are like NP/S ambiguities as in (83a). To see why this is the case, consider the structural reanalysis that takes place in the comparative examples. The initial parse for (82) is a two-place determiner parse, as shown in (84). When this parse is revealed to be erroneous (upon encountering the true main VP) the parser would have to revise the structure to a clausal *than*-clause like (85).

(84)

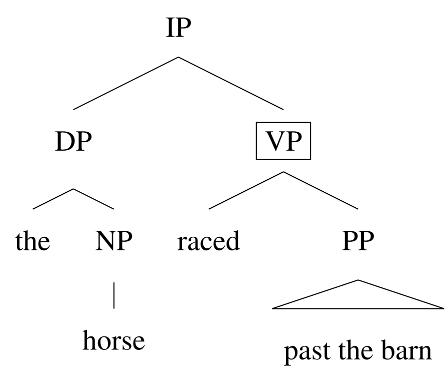


(85)



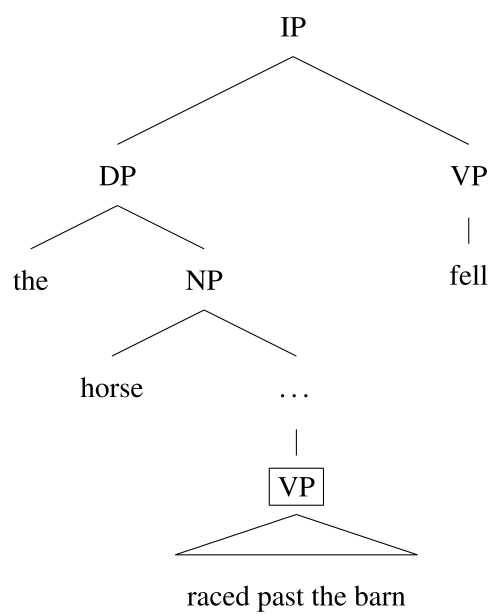
The revision from (84) to (85) requires revising the VP *applauded* from the main VP position to a VP inside of a clausal *than*-clause.[10] The reduced relative clause ambiguity requires a similar revision, as *raced past the barn* is taken as the main VP initially (shown in 86), and must then be revised to modify the subject NP *horse* (shown in 87).

(86)



[10]Further, *applauded* must be revised to take an object, *ballerinas*, that is deleted under comparative deletion.

(87)



One account of reanalysis that predicts the extreme difficulty of (81) and also (82) as compared to structures like (83a) that are relatively easy to reanalyse is the limited-repair account of Lewis (1993, 1998). Lewis' parse involves *link* operations that build structure, and a *snip* operator that destroys local connections. This locality condition allows repair of NP/S revisions as is necessary for (83a), but prevents *snip* from aiding repair of reduced relative clause ambiguities like (81). In these cases, parsing is said to fail and no well-formed representation of the sentence is attained. Lewis' approach, and others like it, make the important claim that the type of structure requiring repair makes a difference to how successfully a sentence is able to be parsed in the end. While I claim that it is true that parsing often fails in the cases of comparatives like (66b), it isn't true that readers are never able to parse reduced relative clause examples, for example. Other factors must be taken into account to then distinguish the unacceptable comparatives like (66b) from other very difficult examples.

2.7.1.2 Evidence signaling reanalysis

Frazier and Clifton (1998) emphasize the influence of the sentence *token* over the sentence *type* in reanalysis. They claim that analyses that are 'semantically confirmed' are more difficult to revise. While *raced* is semantically confirmed as a past tense main verb in (88a), *sent* is not a verb that can generally have an inanimate subject like *the letter* in (88b). Therefore, (88b) does not have the same extreme difficulty as (88a) despite the fact that they contain the same type of ambiguity. The semantic anomaly provides evidence that a repair must take place.

(88) a. The horse raced past the barn fell.

b. The letter sent on Monday arrived today.

While the experimental items in the eyetracking experiment were not designed to encourage the garden path reading through semantic confirmation, the embedded verbs (e.g., *hunted* in (89)) in the experimental items were generally semantically compatible with the garden path analysis (in which they were taken to be the main verb of the sentence).

(89) More whales than sharks **hunted** left for safer waters.

Even more semantic confirmation, in the form of an overt object, is found in examples like (90) (as well as 80).

(90) Osborne (2009): 34

As many cats as dogs eat grass eat grass.

This both furthers semantic confirmation and increases the length of the erroneous analysis. Longer ambiguous regions have been shown to affect reanalysis in grammaticality judgment tasks (e.g., Ferreira and Henderson, 1991), although as Frazier and Clifton note, an increase in length is generally also an increase in semantic commitment.

2.7.2 Reanalysis failure and Grammaticality

Many garden paths can be avoided, for example by adding punctuation or a prosodic break in speech (Kjelgaard and Speer, 1999). For example, the comma in example (91b), from Sturt et al. (1999), prevents the garden path experienced in (91a). As shown in Section 5.1, garden paths in reduced relative clauses can be avoided by substituting an unambiguous lexical item for an ambiguous one (compare 92a-b). Further, Trueswell et al. (1994) claim that even an ambiguous item might not cause the same type of garden path if the correct analysis is the semantically preferred one (although as mentioned above, Frazier and Clifton (1998) argue that semantic factors facilitate reanalysis rather than preventing erroneous initial analyses).

(91) Sturt et al. (1999): 2

a. Before the woman visited the famous doctor had been drinking quite a lot.

b. Before the woman visited, the famous doctor had been drinking quite a lot.

(92) a. The horse raced past the barn fell.

b. The horse ridden past the barn fell.

Whether the right prosody can aid the processing of examples like (66b) remains an empirical question for future research. Although the verbs in the experimental materials were sometimes ambiguous between a transitive and intransitive meaning, the garden path in those comparatives does not rest on any kind of lexical ambiguity. Therefore, an account based on lexical ambiguity resolution as has been proposed for reduced relative clauses (MacDonald et al., 1994; Trueswell and Tanenhaus, 1994; Trueswell et al., 1994) could not explain the difficulty with the comparative examples discussed here.

The results of the eyetracking experiment show that the garden path effect is mitigated when the NP/DP following *than* is something other than a bare plural (and therefore must unambiguously be a DP). This impossibility to negate the garden path without changing fundamental properties of that NP/DP could be the reason why this type of garden path is so persistent, and why these have been claimed to be ungrammatical unlike (91a) and (61ba).

The Impermissible Ambiguity Constraint can be applied to account for ungrammatical comparative clauses in base position. The intuitively worst cases are those like (93), wherein the subject of a clausal than-expression is a plural NP (*dogs*) and the verb in the than-expression has all of its arguments expressed. In other words, these than-expressions are transitive sentences that have undergone only comparative subdeletion. It is in these cases that there is misanalysis of an entire clause. Example (338) shows that this also holds when the verb in the than-expression is intransitive.

(93) Osborne (2009): 34

As many cats as dogs eat grass eat grass. (*judgment Osborne's*)

complete clause: As many cats as dogs eat grass.

(94) ?? More girls than boys sing play guitar.

complete clause : More girls than boys sing.

Although further evidence is required to confirm the judgments, examples (93) and (338) are intuitively more degraded than the examples used in the eyetracking experiment, which have a gap in object position filled by the associate of comparison. I will return to this distinction in Section 2.8.2.

To summarize, degraded comparative clauses in base position have at least three processing strikes against them: the garden path associated with the preference for a two-place determiner structure for *more (than)* when cardinalities are being compared, the difficulty of the structural analysis task, and the lack of semantic information signalling that reanalysis must take place. The first of these sources of difficulty is supported by experimental evidence in Section 2.6, and the other two have independent motivation from the psycholinguistic literature. Further, these examples often allow readers to parse a complete sentence before they receive information that their initial parse is erroneous.

2.7.3 Probabilistic theories

So far, I have shown that independently supported factors that increase difficulty of reanalysis predict extreme difficulty in parsing comparatives like those in the eyetracking experiment. However, these all assume a serial parsing model in which one analysis is pursued until there is evidence that that analysis is erroneous (see Frazier and Fodor, 1978; Frazier, 1978). Other models (e.g. MacDonald et al., 1994) propose that all possible analyses are activated in parallel, with ranked activation (or resource allocation) based on how an interpretation fares on a number of constraints. One type of model of parsing difficulty that works under such a parallel architecture is *suprisal* theory (Hale, 2001; Levy, 2008). *Surprisal* is defined as the "negative log probability of w_i in its sentential context" (Levy, 2008). Under a probabilistic parsing perspective, it is likely that in the comparative/bare plural condition in the eyetracking experiment, the largest part of the pool of processing resources is allocated to the two-place determiner interpretation up to the disambiguating region. Therefore, the surprisal of the main verb (Region 5), which necessitates a re-ranking of parses, is likely to be extremely high. In this respect, suprisal would have similar predictions to a serial model of processing. However, surprisal does not (to my knowledge) have a built-in mechanism for determining when parsing will fail. I have argued that structures like (93) are not ruled out by the grammar, and therefore under a surprisal account some non-zero amount of the probability mass should be assigned to this interpretation. While serial models that include a theory of reanalysis predict that reanalysis might fail in the comparatives discussed, a probabilistic model, at least in its current form, cannot.

2.8 Previous accounts

2.8.1 The Functional Equivalence Account

Section 2.3 showed that our current theory of the syntax and semantics of comparatives does not predict the pattern of acceptable *than*-phrase s in base position.[11] Recently, Osborne (2009) presented a theory-neutral analysis of this pattern, based on the parallels between comparatives and coordination. Key to Osborne's account is his concept of a *Functional Equivalent*, defined in (95). As such, I will refer to Osborne's account as the Functional Equivalence account.

(95) FUNCTIONAL EQUIVALENT OF A [*than*-PHRASE] (Osborne (2009), terminology modified):
A [*than*-phrase] has a functionally equivalent string in the matrix clause if the two could be coordinated (with *and*, *or*, *but*) without altering the word order of the matrix clause.

The Functional Equivalence account presents several generalizations regarding the possible orderings of *than*-phrase s and their functional equivalents. The one that will be of most importance in this paper is that a *than*-phrase splitting its functional equivalent leads to ungrammaticality.

Functional Equivalence predicts the differences between examples (65b) and (66b). In example (96), the *than*-phrase *than girls ordered steak* has a functional equivalent, *boys ordered salad*, in the main clause of the sentence. These can be coordinated without changing the word order of (96a). In (96a), the *than*-phrase follows its functional equivalent, and the sentence is acceptable. In (96c), the *than*-phrase splits its functional equivalent, and is therefore ungrammatical. On the other hand, the *than*-phrase in (97) has no functional equivalent in the main clause of the sentence (as shown by the ungrammatical coordination in (97b), and therefore (97c) does not involve any splitting of a functional equivalent. Example (97c) is therefore grammatical.

(96) a. More boys ordered salad **than girls ordered steak.**

[11] Osborne (2009) does not assume that the complement of *than* is necessarily clausal, as I have in most cases, and reserves the term *than*-clause only for cases where subject, verb and object are pronounced. I will therefore use the term *than*-phrase as a cover term for those complements to *than* that I assume to be clausal, but Osborne (2009) does not.

b. Boys ordered salad and girls ordered steak.

c. *? More boys **than girls ordered steak** ordered salad.

(97) a. More people came to the party **than we invited**.

b. * People came to the party and we invited.

c. More people **than we invited** came to the party.

Osborne (2009) makes further claims about when comparatives are examples of comparative coordination and when they are examples of comparative subordination. Comparative coordination is a term used by Lechner (2001) to describe cases when the *than*-phrase extraposes (under Lechner's analysis) and can then undergo reduction operations normally limited to coordination. For example, *than*-phrase s in comparative coordination structures can undergo gapping, as shown in (98, strikethrough indicates gapped material, Δ stands in for deleted material). Gapping operations are limited to coordination environments such as (99a), and cannot occur in subordinate clauses (99b).

(98) Gapping (Lechner, 2001):

a. Mary bought more books than Sam ~~bought~~ Δ. (Δ = d-many books)

b. More people bought books than Δ ~~bought~~ magazines. (Δ = d-many people)

c. Mary bought books more often than Sam ~~bought books~~ Δ. (Δ = d-often)

d. Mary bought books more often than ~~Mary bought~~ magazines Δ. (Δ = d-often)

(99) a. Mary bought books and Sam ~~bought~~ magazines.

b. * Mary bought books because Sam ~~bought~~ magazines.

Napoli (1983), following Hankamer (1973), claims that English *than* is ambiguous between a prepositional *than* and a coordinator *than*. When *than* is a coordinator, material in the *than*-phrase must be of the same type as the material preceding *than*, as shown in (100), where a verb both preceding and following *than* is grammatical, but a verb preceding and a PP following *than* is not.

(100) Napoli (1983)

a. Mary more often cries than sings.

b. * Mary more often cries than on the porch.

Osborne (2009) defines comparative coordination as the situation where a *than*-phrase has a functional equivalent in the main clause, and appears immediately following this functional equivalent in the linear order of the sentence. The *than*-phrase and its functional equivalent must be like constituents (PPs, VPs, clauses, etc.). Two examples of comparative coordination from Osborne (2009) are shown (along with corresponding coordination examples) in (101) and (102).[12]

(101) a. The boys and the girls sent flowers to him today.

b. More boys than girls sent flowers to him today.

(102) a. The boys sent flowers to him and chocolates to her today.

b. More boys sent flowers to him than chocolates to her today.

The term *comparative subordination* is used by Osborne to describe all examples where a *than*-phrase either does not have a functional equivalent, or does have one but does not immediately follow it. According to Osborne, *than*-phrase s in such examples can undergo the same (and only the same) extraposition operation that applies to other extraposed elements such as PPs and relative clauses. A further observation about comparative subordination states that when a subordinate *than*-phrase does not have a functional equivalent, it must be a full subordinate clause. The evidence for this claim comes from German. The *than*-phrase (or in this case, *als*-phrase) in (103a) has a functional equivalent, *geblieben sind*. In (103b), the functional equivalent is simply *geblieben*, because the *than*-phrase does not include the auxiliary *sind* ('have').

(103) a. weil mehr Leute geblieben sind als gegangen sind.
because more people stayed have than gone have
'because more people stayed than left'

b. weil mehr Leute geblieben sind als gegangen.

(104) a. Mehr Leute als wir eingeladen haben haben geantwortet.
more people than we invited have have answered
'More people than we invited answered.'

[12]The addition of the definite determiner in (101a) is not discussed in Osborne (2009) and will not be taken up here.

b. * Mehr Leute als wir eingeladen haben geantwortet.

In (104), however, the *als*-phrase does not have a functional equivalent, due to V2 affecting the verb ordering in the main clause but not in the *als*-phrase. Osborne claims that because of this lack of functional equivalent, the *als*-phrase must be a full clause, i.e., it must contain the auxiliary *haben*.

The Functional Equivalence account brings together a set of data that did not previously have a unified account. However, Functional Equivalence as an account is purely descriptive; Osborne (2009) gives us no reasons as to *why* functional equivalence should be the source of any linguistic generalizations. Functional Equivalence is claimed to apply at the level of surface syntax. However, we have no independent evidence that our language faculties keep track of what can be coordinated in deciding on possible linear orders of words in the surface syntax, outside of actually producing or comprehending coordinations. That comprehenders have trouble recovering from certain garden paths in processing, however, has a great deal of empirical support.

Further, while Functional Equivalence predicts the difference between examples like (96) and (97), it would not predict the differences in the eye movement record between comparatives with bare plural subjects and those with proper name subjects. The object gap in the comparative clauses that was introduced to parallel the relative clause conditions also eliminates the possibility of coordination of the *than*-phrase and the main clause, as shown in (105b) and (105d).

(105) a. More nurses than patients thanked cared a great deal about their jobs.

b. *Nurses cared a great deal about their jobs and patients thanked.

c. More nurses than Percival thanked cared a great deal about their jobs.

d. *Nurses cared a great deal about their jobs and Percival thanked.

The evidence from the eyetracking study that bare plural subjects cause greater processing difficulty than definite DPs supports the idea that the acceptability of comparative clauses in base position is due to processing factors and not to grammatical constraints like Functional Equivalence.

2.8.2 Subcomparatives in base position

While the processing account predicts the observed experimental effects that are not predicted by Functional Equivalence, a potential problem for the processing account is that not all of Osborne (2009)'s degraded examples have a bare plural in the subject position of the *than*-clause. These degraded examples fall under the category of base position clausal *sub*comparatives, or rather comparative clauses in base position that have undergone comparative subdeletion (Bresnan, 1975). I will discuss two accounts in the literature on comparatives that rule out base position subcomparative clauses through grammatical means. Pinkham (1985) gives a semantic account, while Hendriks (1995) gives a syntactic account.

Pinkham (1982) makes the generalization that comparative clauses in base position must undergo comparative deletion, rather than simply comparative subdeletion. In other words, while some comparative clauses can appear in base position, subcomparative clauses in general cannot. For example, (106b), which has comparative *sub*deletion (of *d-many*) is degraded in comparison to (106a), which is a comparative (with comparative deletion of *d-many men*). Pinkham suggests that this difference does not merely reflect a difference in acceptability between comparatives and subcomparatives in general, as acceptability is improved when a subcomparative is in extraposed position (e.g., 106c). However, example (106c) is still reported to be slightly degraded.

(106) Pinkham (1982): Ch.2, 6-8

a. More men than the company was willing to hire __ came for an interview.

b. *More women than the company was willing to hire men came for an interview.

c. ?More women came for an interview than the company was willing to hire men.

Functional Equivalence can rule out examples like (106b), because the *than*-clause has a functional equivalent in the main clause.

(107) More [women came for an interview] and [the company was willing to hire men.]

However, new machinery must be introduced in Functional Equivalence to avoid ruling out some base position subcomparatives that are less degraded, like (108) and (109).

(108) Pinkham (1982):

? More passengers than the airline had issued tickets tried to board the plane.

(109) Bresnan (1976):

Fewer women than there are fingers on my right hand passed.

In order to rule *in* examples like (108) and (109), Osborne introduces the notion of *compared constituents*, and stipulates that when a comparative clause is a full clause (with all arguments expressed), compared constituents must have the same 'syntactic function'. While the definition of compared constituents is not explicitly stated, the compared constituents appear to be the associate of comparison in the main clause and the constituent in the comparative clause that is the restrictor of the Degree Phrase. Osborne explains that in the ungrammatical examples like (93), the compared constituents *cats* and *dogs* are both subjects. Therefore, the comparative clause has a functional equivalent in the main clause, and the comparative clause cannot be in base position. However, for the more acceptable examples, the compared constituents differ in their syntactic role between the main clause and the comparative clause. For example, *passengers* in (108) is in subject position, while its compared constituent *tickets* is an object. In this case, there is no Functional Equivalent to the comparative clause, and therefore the comparative clause can appear in base position.[13]

Pinkham attributes the distinction between examples like (106a) and (106b) as a difference in the *scope* of the comparative clause. *Wide* scope is defined as the requirement that the entire sentence be used to interpret the quantification contributed by *more*, while *narrow* scope requires only that the comparative clause be used to interpret *more*. Pinkham suggests that comparative clauses that have wide scope may not appear in base position, and that subcomparative clauses necessarily take wide scope. Therefore, subcomparative clauses may not appear in base position.

Hendriks (1995) questions Pinkham's scope distinction, suggesting that the amount of the sentence required for interpretation in each case is in fact the same. Instead, Hendriks locates the constraint against subcomparative clauses in base position (what Hendriks calls *sentence-internal*

[13]There is another reason why this particular example is relatively acceptable. The verb *issue* might be interpreted as transitive, as in (i). The example could then be interpreted as in (ii), where there is an object gap corresponding to *passengers* in the comparative clause.

i. The flight attendant issued him a ticket.

ii. More passengers than the airline had issued ~~*d-many passengers*~~ tickets tried to board the plane.

If readers compute this interpretation, then (108) would be predicted to be acceptable on both the processing and Functional Equivalence accounts.

than-clauses) in the syntax of comparatives. Like some other previous accounts, Hendriks argues for two different *than*s in English (and Dutch, the language Hendriks analyses primarily); one that acts as a preposition (introducing subordinate *than*-phrases) and one that acts as a conjunction (introducing coordinated *than*-phrases). While I will not present Hendriks's full categorial grammar analysis here, the descriptive idea is that comparative clauses that have undergone comparative deletion are instances of comparative *subordination*, while subcomparative clauses (that have undergone only comparative subdeletion) are instances of comparative coordination. Subordinate *than*-phrases such as the one in (110), repeated from (106a), are licensed in base position, much like a relative clause would be. However, coordinate *than*-phrases may not appear in base position because they create an ill-formed coordination between the associate of comparison (*women* in example (111), repeated from (106b)) and the complement of the *than*-phrase because the two are of different syntactic categories.

(110) More women [than$_P$ the company was willing to hire] came for an interview.

(111) *More [$_{NP}$women] [than$_{Conj}$ [$_{CP}$the company was willing to hire men]] came for an interview.

The motivation for separating comparative deletion and subdeletion by the analysis of *than* is that for subcomparative clauses in extraposed position, we find reduction operations such as gapping that can only occur in coordinate structures, and not in subordinate structures. This distinction is shown in (112), where (a) and (b) show coordinate and subordinate structures, respectively, and (c) shows gapping in a subcomparative clause.

(112) Hendriks (1995): 12, ch. 2

a. Paula kuste Tom en Sue Δ Peter.
   Paula kissed Tom and Sue Peter

b. *Paula kuste Tom toen Sue Peter Δ.
   Paula kissed Tom when Sue Peter

c. Paula kuste meer jongens dan Sue meisjes Δ.
   Paula kissed more boys than Sue girls

The motivation for the prepositional status of *than* in (111) appears to mainly be the *than*-phrase's similarity to a relative clause. While these two structures are superficially similar, in Chapters 3-4 I will show that these two structures do show important differences.

The processing account developed in this chapter does not account for a ban on subcomparatives in base position, as these examples do not all have a garden path due to preference for a two-place determiner *more*. However, these examples may create a different type of processing difficulty. Future research will explore the idea that the degree argument in a comparative clause may behave as an *active filler* (Crain and Fodor, 1985; Frazier and Flores D'Arcais, 1989; Frazier and Clifton Jr., 1989; Stowe, 1986). Frazier and Clifton Jr. (1989) showed that NPs have longer reading times when they are in a position that could have served as a gap corresponding to a moved wh-item. For example, *the guests* would have longer reading times in (113a) than it would in (113b).

(113) Frazier and Clifton Jr. (1989)

a. Who did the housekeeper from Germany urge the guests to consider?

b. The housekeeper from Germany urged the guests to consider the new chef.

It is possible that in (106b), (and also possibly in (106c), *men* produces a similar kind of 'filled-gap' effect (Crain and Fodor, 1985; Stowe, 1986). That degree arguments might behave as active fillers isn't surprising given current theories of comparatives, as these theories often include movement of a wh-operator corresponding to the degree argument to the front of a clausal *than*-clause.

(114) Pinkham (1982): Ch. 2, 53-54

a. *More men than women use Chanel #5 use Eau Sauvage.

b. More men use Eau Sauvage than women use Chanel #5.

2.8.3 Gaps in comparative clauses

The Functional Equivalence account also states that acceptability will be degraded when a Functional Equivalent *precedes* its *than*-clause. Examples (115b) and (116b) are degraded with respect to their extraposed counterparts (the a examples). Osborne notes that there are conflicting reports about the acceptability of (115b) and (116b), but that Lechner (2001, 2004) and Pinkham (1982) claim them to be grammatical.

(115) Osborne (2009): 22

a. More people bought books than sold them.

b. ?? More people than sold books bought them.

c. More people [bought books] and [sold them/books].

(116) Osborne (2009): 23

a. More people were in the house than in the yard.

b. ?? More people than in the yard were in the house.

c. More people were [in the house] than [in the yard].

In (115b) and (116b), readers/hearers encounter a verb or preposition following *than*, which in principle should disambiguate toward a clausal *than*-clause and away from a two-place determiner interpretation. However, these sentences may still be degraded when compared to examples like (117).

(117) More friends than we talked to __ were at the party.

__ = *d*-many friends

Intuitions and preliminary evidence suggest that subject gaps in comparative clauses, like (177) are more difficult to process than object gaps, like in (117). This intuition will be explored in detail in Chapter 3, and the penalty for subject gaps in comparative clauses will be supported by experimental data.

(118) More friends than __ talked to us were at the party.

__ = *d*-many friends

This pattern is the opposite of what we find with relative clauses, where subject gaps are generally easier to process than object gaps (e.g., Gibson, 1998; King and Just, 1991; Wanner and Maratsos, 1978). A complete account of *than*-clauses in base position will have to explain why disambiguation by verbs and prepositions is more difficult than disambiguation by a nominative (and therefore subject) pronoun like *we* in (115b). It could be the case that encountering information that conflicts with predictions and also filling in a gap at the same point in processing creates difficulty.

Osborne (2009) is also able to account for the unacceptability of examples like (119a, discussed by Pinkham (1982)) under the constraint that a *than*-clause must not precede its Functional Equivalent. In (119a), the *than*-clause has presumably been reduced from *d-many people bought magazines*. That (119a) is impossible is also straightforwardly accounted for by the Unparsable Grammaticality account, again without the stipulation required for the Functional Equivalence account. In (119a), a bare plural follows *than* and will preferentially be taken as an NP complement, causing an analysis of the sentences that is highly implausible (namely, that magazines bought books). The parser has no successful means of reanalyzing the sentence to have the meaning of (119b).

(119) a. # More people than magazines bought books.

b. More people bought books than magazines.

2.9 Concluding Remarks

In this chapter, I have claimed that there is no need to introduce new grammatical constraints into our theory of the syntax and semantics of comparatives in order to explain why some *than*-clauses are unacceptable in base position. Rather, the degraded status of some *than*-clauses in base position can be explained by the fact that they are exceedingly difficult to process. I presented evidence from an experiment of eye movements during reading showing that readers initially predict a two-place determiner interpretation of *more (than)* with *than*-clauses in base position, resulting in garden path effects that are potentially prohibitive to forming a legal representation of the sentence. That the source of degraded acceptability in Osborne (2009)'s examples is due to processing facts is a very desirable conclusion from the point of view of linguistic theory. The grammatical constraints that would need to be introduced would distinguish between examples on the basis of the internal properties of *than*-clauses, including the type of DP that forms the subject of a comparative clause. These properties have not been claimed to influence the syntax or semantics of the *than*-clause as a whole, and therefore should not affect where the *than*-clause can attach in the overall structure of the sentence.

The claim that extreme parsing difficulty has led to the perception of ungrammaticality in some of Osborne's examples raises the question of what leads to this perceptual effect, and whether linguists' intuitions can distinguish between different sources of degraded status. In recent years, new sources of ungrammaticality have been introduced. For example, Gajewski (2002) introduces the idea that ungrammaticality can arise when sentences are necessarily semantically trivial. While the idea that perceived ungrammaticality can stem from sources other than generative grammar is not new (e.g., Chomsky and Miller, 1963)), in the case of comparatives the distinction between ungrammaticality and unparsability deserves further consideration.

CHAPTER 3

GAPS IN COMPARATIVE CLAUSES

3.1 Introduction

Theories of the structure of comparatives have exploited the similarities that comparatives bear to other well-studied syntactic constructions. For example, the comparative in (120b) has much in common with the coordinate structure in (120a). Similarly, the comparative in (121b) looks much like the relative clause example (121a). These particular similarities have provided the basis for syntactic theories of comparatives (e.g., Lechner, 2001, 2004; Bhatt and Pancheva, 2004, inter alia).

(120) a. Some students went to the library and went to the pub for drinks.

b. More students went to the library than went to the pub for drinks.

(121) a. The actors that the audience praised were mentioned in the newspaper review.

b. More actors than the audience praised were mentioned in the newspaper review.

In this chapter, I will focus on the similarities and differences between relative clauses and comparative clauses like (121a) and (121b), respectively. I will show that despite their surface similarity, they show surprising differences in processing and acceptability judgments that have not yet been accounted for in the literature. Specifically, evidence presented in this chapter supports the intuitive judgment that in comparative clauses, gaps left by Comparative Deletion in subject position (122a) are degraded and cause processing difficulty in comparison to gaps in object position (122b). This result is unexpected in light of what we know about the processing of relative clauses and other related structures. Psycholinguistic experiments have long shown that in relative clauses, gaps in object position (as in 123a) are associated with an increase in processing difficulty as compared to gaps in subject position (123b) (e.g., King and Just, 1991; Wanner and Maratsos, 1978).

(122) a. # More students than __ contacted the professor were likely to fail the class.

b. More students than the professor contacted __ were likely to fail the class.

(123) King and Just (1991):

a. The reporter who the senator attacked admitted __ the error.

b. The reporter who __ attacked the senator admitted the error.

(124) *Subject gap penalty in comparative clauses*:

In comparative clauses, subject gaps are more difficult to process and show lower acceptability than object gaps.

The goals of this chapter are to first present the data that show the subject gap penalty, and second to begin to determine what the critical difference is between comparative clauses and relative clauses that gives rise to the subject gap penalty. Discovering the source of the penalty is a challenge because, while comparatives and relative clauses share surface properties and basic phrase-structure architectures, they also have important differences at several different levels of representation and processing. For instance, there are critical differences between comparatives and relative clauses both in meaning and function. The function of comparatives is to express comparison in language, where comparison has been argued to be a cognitive need (Stassen, 1985; Kennedy, 2007a), or an 'intellectual operation' in a class with negation and predication (and possibly assertion) (Campbell and Wales, 1969). In contrast, relative clauses are modifiers that restrict a set of entities under discussion, in other words picking out those members of a set that are of interest.[1]

The differences in the meaning and function of comparative and relative clauses are encoded in the formal semantics of each structure. The encoding of comparison in the semantic system has been modeled in several ways, including using covert thresholds (Schwarzschild and Wilkinson, 2002; Schwarzschild, 2008) or degrees (von Stechow, 1984; Kennedy, 1999). Here I will use degree semantics for comparatives, but I do not believe that the results of this chapter would decide between the two approaches.[2] Degrees are generally encoded into the meaning of adjectives, so that an adjective like *young* would have a semantic denotation like (125). Both (126) and (127) contain

[1]In this chapter, I will only discuss restrictive relative clauses. Non-restrictive relatives are likely to have a processing profile that is different from both comparatives and restrictive relative clauses, but these differences are left out of the current discussion.

[2]In Chapter 2, I proposed that some comparatives need not include degrees in their representations, but rather may simply be based on comparisons of cardinalities. For comparatives with (underlyingly) clausal complements to *than*, I maintain a degree analysis.

this adjective, and therefore have degrees represented in their semantics. How the comparative clause in (127) differs from the relative clause in (127) is that the comparative clause underlyingly has an instance of *young* inside of it while the relative clause does not. This is shown in (128). Therefore, there is a second degree represented in the comparative clause headed by *than* (which is then abstracted over by a process of lambda abstraction in the semantic representation) whereas there is no new degree in the relative clause in (126).

(125) [[*young*]] = $\lambda d.\lambda x.\ x$ is d-young

(126) Young actors that the audience praised were mentioned in the newspaper review.

(127) Younger actors than the audience praised were mentioned in the newspaper review.

(128) Younger actors [than λd. the audience praised ~~*d-young actors*~~] were mentioned in the newspaper review.

At the level of parsing, as shown in Chapter 2, comprehenders have expectations about the structure of the complement of *than* that differ from expectations about the structure of a relative clause. Specifically, while (129a) may be initially misanalyzed as having a bare plural complement to *than* (creating a structure like 129b), no such initial misanalysis is possible in the corresponding relative clause (129c).

(129) a. More students than professors encouraged signed the petition.

b. More students than professors signed the petition.

c. The students who professors encouraged signed the petition.

These differences in both representation and processing between comparatives will be explored as possible explanations for the asymmetry in processing gaps that is found between the two structures. In this chapter, I will first present new experimental data showing the penalty for subject gaps in comparative clauses. Then, I will summarize an analysis based on focus resolution that has been proposed in the literature Bhatt and Takahashi (2011b), and show that this analysis does not predict the full range of empirical data. I will also consider an account based on processing complexity due to the requirement in sentences like (122a) to revise grammatical predictions and simultaneously resolve a filler-gap dependency. This hypothesis is tested in a study a structure that shares this same requirement outside of the domain of comparatives. The results of the study are equivocal, and suggest that this processing effect is not at the heart of the subject gap penalty in comparative clauses. While this chapter presents a detailed empirical picture of the subject gap penalty, it therefore does not provide a satisfying account of why the subject gap penalty exists. In Chapter 4, I will sketch a more promising account based on island violations that makes correct predictions regarding the data presented in both chapters. Before turning to the empirical data on comparative clauses, I will review a subset of the previous results on the processing of gaps in relative clauses in the literature, and the theories that have been proposed to account for these effects.

3.2 Theories of relative clause processing

A number of proposals have been put forth in the psycholinguistics literature to account for the asymmetry between subject gaps and object gaps in relative clause constructions. Some of these proposals claim that the complexity associated with processing a relative clause depends on the time and/or intervening lexical material between the head of the relative clause and its gap. These theories rest on costs associated with storage of the relative clause head over time, integration of the relative clause head into the gap site, or interference in retrieving the relative clause head at the gap site. Other accounts propose that the processing costs associated with relative clauses are due not to the amount of lexical material intervening between the head of the relative and the gap site, but the amount of syntactic structure intervening. Still other theories of processing complexity rest on the information structure of the relative clause, or the frequency of occurrence of the structure in question, or the nature of the gap-filling process more generally. In this section I will briefly introduce a selection of the most prominent theories of relative clause processing complexity, before discussion the predictions that these well-known theories would make for the processing of comparative clauses.

3.2.1 Storage, integration and interference in processing relative clauses

One prominent class of accounts of the increased processing complexity of object relative clauses as compared to subject relative clauses proposes that the asymmetry is due to the increased dependency length between the head of the relative clause (*reporter* in 130-131) and the gap site, as well as interfering discourse referents have been proposed to be the source of the difficulty with object relative clauses such as (131) as compared to subject relative clauses such as (130) (Gibson, 1998, 2000; Lewis and Vasishth, 2005; Warren and Gibson, 2002).

(130) The reporter who __ attacked the senator admitted the error.

(131) The reporter who the senator attacked __ admitted the error.

Gibson (1998, 2000)'s Dependency Locality Theory includes a theory of complexity due to *integration* cost[3]. This integration component (reproduced in 132) states that processing resources (defined in terms of energy units) are required to process newly introduced discourse referents in the linguistic input. Each new discourse referent that intervenes between the tail and head of a dependency incurs a cost to processing complexity.

(132) DLT structural integration cost (Gibson, 2000):

The structural integration cost associated with connecting the syntactic structure for a newly input head h_2 to a projection of a head h_1 that is part of the current structure for the input is dependent on the complexity of the computations that took place between h_1 and h_2. For simplicity, it is assumed that 1 EU [energy unit] is consumed for each new discourse referent in the intervening region.

In example (130), a subject relative clause, the dependency between the head of the relative clause *reporter* and the gap site does not span any new discourse referents, so the predicted cost is 0 EUs. However, in the object relative case (131), the dependency between *the reporter* and the gap site spans two new discourse referents, *the senator* and *attacked*. Therefore, the predicted cost to integration is 2 EUs.

Lewis and Vasishth, 2005 (see also Lewis et al., 2006) present an account couched in the ACT-R framework of for modeling cognition, and while this account differs from the DLT in the source of the object gap penalty, also relies on the intervening elements in a dependency. This theory claims that, at a gap site, a cue-based search is initiated for the gap's filler, which has potentially decayed in activation since being processed initially. When intervening material (for example intervening NPs in examples like 131) shares cues with the target of the search, there is a cost to retrieval.

[3]The DLT also includes a component dealing with the costs of *storage*, defined as the number of required predicted heads.

3.2.2 Structural Distance

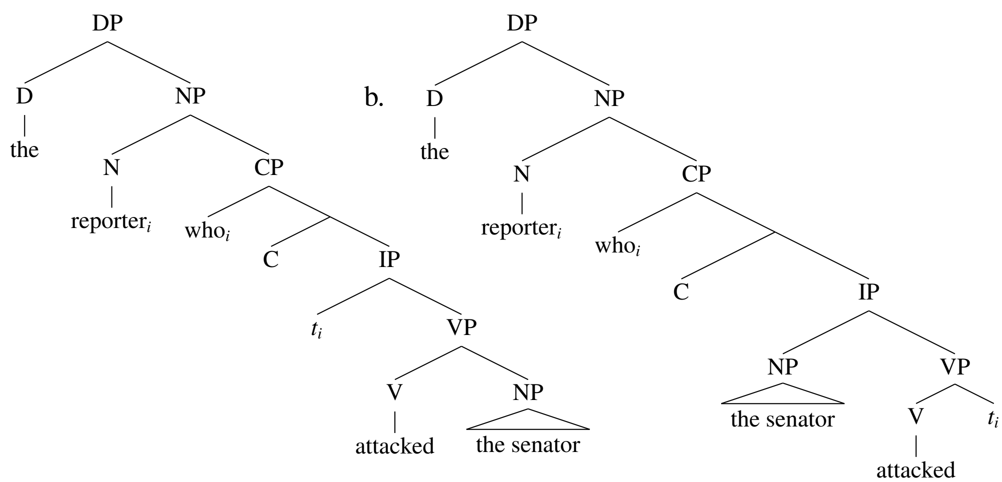
In contrast to accounts that point to the linear distance (and the linear intervening material) between a relative clause head and its gap site as the predictors of increased processing complexity, O'Grady et al. (2000) propose that it is *structural* distance that determines processing complexity in relative clauses.

(133) The Structural Distance Hypothesis (O'Grady et al., 2000):

The distance traversed by a syntactic operation, calculated in terms of the number of nodes crossed, determines a structure's relative complexity.

Subject relative clauses have representations like (134a) (I leave a discussion of theoretical relationship between filler and gap site in relative clauses until Chapter 4). There is only one node crossed between the gap site and the head. For object relatives, the number of nodes crossed is greater than 1. O'Grady et al. state two nodes, VP and S, are crossed in object relative clauses, corresponding to VP and IP in (134b).

(134) a. b.



For languages like English, the Structural Distance Hypothesis makes the same predictions as those based on linear distance, that object relatives are more complex than subject relatives. Where the two accounts diverge, however, is in their predictions about languages with pre-nominal relative clauses. Studies of Japanese (Miyamoto and Nakamura, 2003; Ueno and Garnsey, 2008), Korean (Kwon et al., 2010) and Mandarin (Chen et al., submitted; Lin and Bever, 2006) have provided support in favour of structural distance over linear distance by showing an advantage for subject relatives, which in these languages have a longer linear distance from gap site to relative clause head (although see Hsaio and Gibson, 2003; Gibson and Wu, in press; Chen et al., 2008). I will return to the discussion of pre-nominal relative clauses in Chapter 4.

3.2.3 Perspective maintenance

MacWhinney (1982) presents an account of relative clause processing (among other effects) based on the concept of perspective (MacWhinney, 1977) defined as “the way a speaker or a listener becomes actively involved in a sentence" (p. 152). According to MacWhinney’s proposal, speakers and comprehenders of language take on the perspective of a participant, the subject, in a sentence as part of determining a starting point for sentence production or comprehension. For example, when beginning to read (143), the reader would take the perspective of the reporter.

(135) The reporter attacked the senator.

Some sentences require the perspective to shift over the course of a sentence. MacWhinney (1982) proposes that in general, speakers or readers will by default retain the perspective they initially take, and that shifts in perspective (especially those that are not overtly signaled) are marked and may cause difficulty or complexity.

(136) The Perspective Maintenance Hypothesis (MacWhinney, 1982):

The perspective of the main or first clause will also be the perspective of the subordinate or conjoined clauses, unless perspective is expressly shifted.

The Perspective Maintenance Hypothesis makes predictions for the processing of relative clauses. For subject relative clauses in subject position (e.g., 137a), the reader can maintain one perspective throughout the sentence, namely that of the reporter. Of modifiers in object position, subject and object gaps each are said to require one shift in perspective according to MacWhinney. In (137d), the reader must shift perspective from the editor to the senator once this NP is reached. In (137d), the relative pronoun and gap indicate that there must be a shift toward the reporter as a perspective. Finally, the subject modifier, object gap (137b) combination is proposed to be the most difficult by the Perspective Maintenance Hypothesis. In this case the comprehender must shift perspective from the reporter to the senator, and then shift *back* to taking the reporter as perspective for the rest of the main clause.

(137) a. *Subject modifier, subject gap*: The reporter who __ attacked the senator admitted the error.

b. *Subject modifier, object gap*: The reporter who the senator attacked __ admitted the error.

c. *Object modifier, subject gap*: The editor spoke to the reporter who __ attacked the senator.

d. *Object modifier, object gap*: The editor spoke to the reporter who the senator attacked __ .

MacWhinney cites several studies that are congruent with the Perspective Maintenance Hypothesis, and found no counter-evidence in the literature on processing relative clauses. However, Gibson et al. (2005) conducted a reading time experiment with all of the conditions in (137), in which the predictions of the Perspective Maintenance Hypothesis were not borne out. Gibson et al. found that object gaps were associated with longer reading times than subject gaps in both subject-modifying and object-modifying relative clauses (with a 33ms per word difference on average), with no significant interaction between the two factors. The number of perspective shifts would predict that the difference between subject and object gaps in subject position should have been larger than the object-modifying conditions.

3.2.4 Semantic indeterminacy, frequency and surprisal

Gennari and MacDonald (2008, 2009) have argued for an account of the subject/object gap asymmetry more aligned with constraint-based theories of sentence processing (e.g., Trueswell and Tanenhaus, 1994). Gennari and MacDonald propose that object relative clauses with animate head nouns have increased *semantic indeterminacy* over object relative clauses with inanimate heads and subject relative clauses. In a gated sentence completion study, Gennari and MacDonald (2008) show that when subjects are given the prompt (138a) up to the point of *that*, subjects completed the sentence most often with a subject relative clause with the head of the relative fulfilling an Agent role 45% of the time, an Experiencer 25% of the time and Patient of a passive 5% of the time). In contrast, with an inanimate head (138b), subjects' completions at the point of *that* were 65% object relative clauses (with the head as Theme) and 35% passive relative clauses with the head noun as Theme.

(138) a. The director that the movie...

b. The movie that the director...

When the prompts were given up to the point of *the*, a subject relative clause was no longer possible. Still, Gennari and MacDonald found that there was greater variation in the thematic role fulfilled by the head of the relative clause when it was animate (varying between Goal, Patient and Theme) than when it was inanimate (in which case it was the Theme 82% of the time and a Location 7% of the time). The authors interpret this result as an indication that object relative clauses with animate heads have a greater semantic indeterminacy, which leads to greater processing difficulty. This analysis was supported by evidence from a reading-time study which showed effects of animacy in processing object relative clauses beginning at the subject of the relative clause.

A related theory of sentence parsing in general is based on the notion of *surprisal*, as proposed by Hale (2001) and Levy (2008). Surprisal relates processing difficulty of a given word to the probability with which that word occurs in a particular context. More specifically (based on the version of the is theory proposed by Levy (2008)), the difficulty of processing a word is proportional to the negative log-probability of that word in context. If a word is close to zero in probability, its surprisal value will be high (increasing exponentially as probability approaches zero) and therefore its processing difficulty is predicted to be high. If a word is completely predictable in context, then surprisal will be at zero and processing difficulty will be predicted to be low. Under the surprisal hypothesis, object relative clauses are predicted to have increased processing difficulty over subject relatives because object relatives are less frequent in language use, and therefore have a greater surprisal value than subject relatives.

3.2.5 Discourse and relative clauses

Recently, Roland et al. (2012) examined experimental and corpus data to show that the penalty for object relative clauses may be due to discourse factors, following previous studies by Reali and Christiansen (2007) and Mak et al. (2008). While Roland et al. indicate that they were not ruling out a combination of multiple factors that determine relative clause processing difficulty, they provide results from several studies to support the claim that the role of discourse information in processing relative clauses may be greater than has previously been understood. For example, Roland et al. show using a self-paced reading task that having a preceding context sentence that introduces the NP within the relative clause is associated with shorter reading times on the relative clause verb as compared to a neutral preceding context (their Study 3). A subsequent study showed that it is not the mere mention of the embedded NP that matters the most to relative clause reading times, but rather the topichood of that NP in the preceding context.

3.2.6 The Active Filler Hypothesis

The final theory I will discuss that predicts the difference in processing difficulty between subject and object relative clauses is the Active Filler Hypothesis (Crain and Fodor, 1985; Frazier and Flores D'Arcais, 1989; Frazier and Clifton Jr., 1989; Stowe, 1986). The Active Filler Hypothesis holds that once a filler (for example a relative pronoun) is encountered, the parser actively posits a gap in the earliest possible position. When the earliest potential gap site turns out not to be the actual one, so-called *filled-gap* effects can occur (Crain and Fodor, 1985; Stowe, 1986). For example, in (139a), there is potential gap site following *urge*, but the true gap site is in the object of *consider*. Frazier and Clifton Jr. (1989) found longer reading times on *the guests* in (139a) than (139b), showing that readers were not expecting the direct object to *urge* to be realized as an overt DP.

(139) Frazier and Clifton Jr. (1989)

a. Who did the housekeeper from Germany urge the guests to consider?

b. The housekeeper from Germany urged the guests to consider the new chef.

For relative clauses with overt relativizes, the Active Filler Hypothesis predicts the relative processing difficulty of object gaps over subject gaps. This is because once the relative pronoun or complementizer filler is encountered, there is a potential gap site immediately in subject position. If this subject position is filled with an overt DP, as it is with object relatives, then the earliest possible gap site is disconfirmed.

3.2.7 Predictions for Comparative Clauses

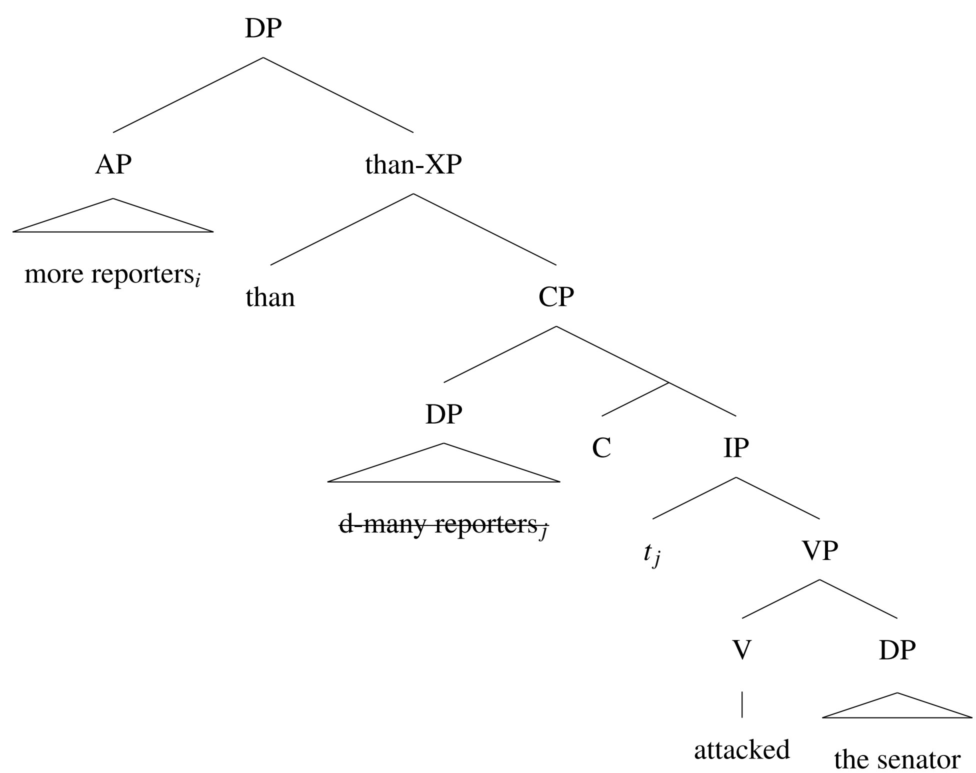
In the previous sections, I summarized several competing theories for the source of the object gap penalty in processing relative clauses. In this section, I will support the claim that whatever the source of difficulty with (at least some) object relative clauses turns out to be, it is unlikely that the same principles could predict the reverse pattern for comparative clauses (I will return to this issue in Section 3.4.2). In terms of linear distance, comparatives and relative clauses can have identical amounts and types of intervening material between the 'head' and the gap site, as shown in (140-141).

(140) The dogs that the cat/I/someone chased (across the field) ended up getting away.

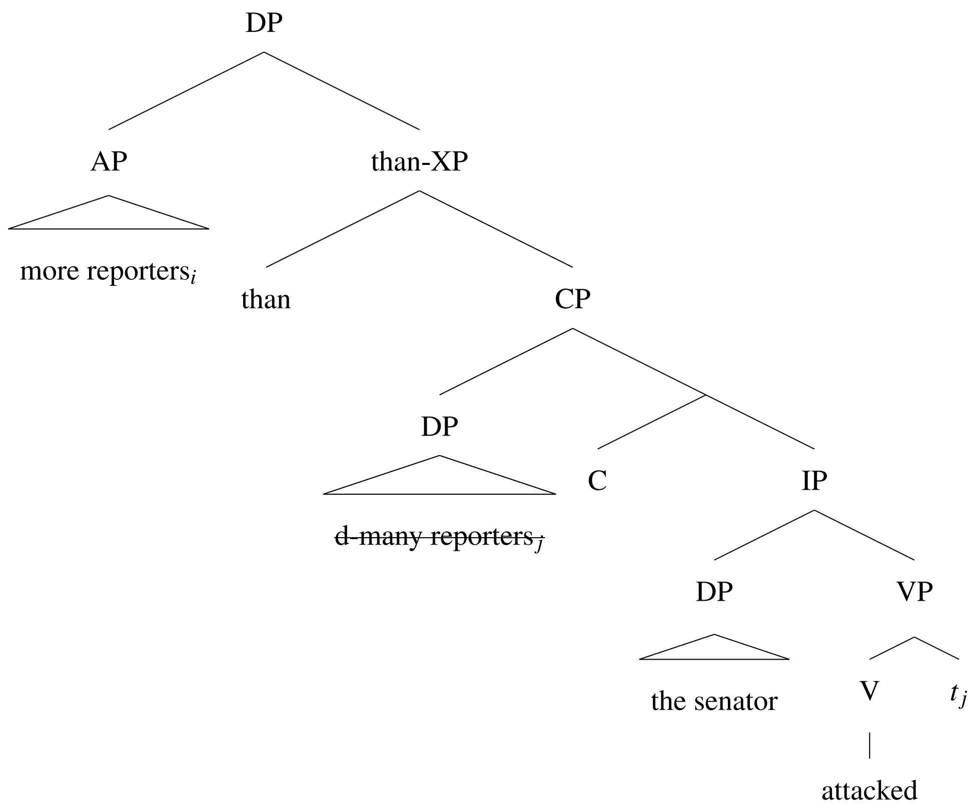
(141) More dogs than the cat/I/someone chased (across the field) ended up getting away.

Likewise, the difference in structural depth between subject and object gaps in comparative clauses should be similar between comparative and relative clauses, as shown in (142). The tree in (142a) shows a subject gap in a comparative clause, and (142b) shows an object gap. As in relative clauses, the object is structurally deeper than the subject.

(142) a.



b.



As discussed above, MacWhinney (1982) proposed that it is the number of shifts in perspective that creates processing difficulty for object relative clauses over subject relatives. Like the accounts that rest on linear or structural distance, the Perspective maintenance account would not straightforwardly predict any differences in the pattern between relative clauses and comparative clauses, as each have one embedded clause that either maintains perspective (in the case of subject gaps) or changes perspective (in the case of object gaps) from the main clause subject.

The accounts based on frequency or semantic indeterminacy, such as Gennari and MacDonald (2008), differ from those based on linear or structural distance in that they do not necessarily predict an identical pattern of results for relative clauses and comparatives. Further study will be needed to determine whether there are strong differences in (in)determinacy between subject and object gaps in comparative clauses, or whether there are strong differences in frequency between the two types of comparative clauses. However, while Chapter 2 showed that readers expect a simple NP complement after sentence fragments like (143), both the nominative pronoun *we* in (144) and the verb in (145) disambiguate toward a clausal complement to *than*. This could be one indication that the semantic indeterminacy of (144) and (145) may not differ in a way that predicts the subject gap penalty.

(143) More people than...

(144) More people than we...

(145) More people than walked...

Finally, the Active Filler Hypothesis would predict that, if the filler of the gap in comparative clauses were an active filler, then gaps in comparative clauses would behave like those in relative clauses and there would be a penalty for object gaps over subject gaps.

To summarize, none of the theories discussed for relative clauses can straightforwardly apply to comparative clauses. Therefore, some other explanation is required to explain the pattern presented in (122). Section 3.3 presents experimental evidence that subject gaps are associated with processing difficulty compared to object gaps, and will add to the empirical pattern that a theory of gaps in comparative clauses must address.

3.3 Experimental Data

This section will present evidence from sentence processing to support the intuitive judgment that subject gaps in comparative clauses are difficult or degraded in comparison to object gaps. Experiment 2 used self-paced reading to examine the processing of subject and object gaps in comparatives with comparative clauses in what I will call *base* position, to the immediate right of the associate of comparison, and what I will call *extraposed* position, to the right of the main VP of the sentence.

3.3.1 Experiment 2

In this experiment, subjects read sentences with comparative constructions in a phrase-by-phrase self-paced reading paradigm. The goal of the study was to test whether the intuition that subject gaps in comparative clauses carry a processing penalty over object gaps is robust in a controlled empirical study. A secondary goal of Experiment 2 is to test whether the subject gap penalty, if it does hold up to empirical testing, exists equally for the two possible positions of comparative clauses: base position, which immediately follows the associate of comparison, or extraposed position, which follows the main VP of the sentence. The extent to which the effects differ for the two linear positions in which comparative clauses may appear may provide insight into the source of the subject gap penalty.

3.3.1.1 Methods and Procedure

3.3.1.1.1 Materials Twenty-four sets of sentences like those in (1a-d) were devised. The experiment manipulated the type of gap in the comparative clause (subject vs. object), which I will refer to as the Gap Type manipulation, and the linear position of the *than*-phrase in the sentence (*base* vs. *extraposed* position), which I will call the Than-phrase Position. The non-extracted DP in the *than*-phrase was a first or second person pronoun. These were chosen to provide case information disambiguating toward a clausal *than*-phrase in the object extraction conditions, eliminating the possibility of a garden path effect like those described in Chapter 2. Further, the pronouns were also meant to prevent the introduction of further referential complexity into the sentences (Warren and Gibson, 2002).

1. a) Object Extraction, Base Position

   More friends / than we talked to / were at the party, / according to the pictures on Facebook.

   b) Object Extraction, Extraposed

   More friends were at the party than we talked to, according to the pictures on Facebook.

   c) Subject Extraction, Base Position

   More friends than talked to us were at the party, according to the pictures on Facebook.

   d) Subject Extraction, Extraposed

   More friends were at the party than talked to us, according to the pictures on Facebook.

3.3.1.1.2 Procedure 72 UMass undergraduates participated for psychology course credit. The experiment was presented using Linger software (Rohde, 2001, http://tedlab.mit.edu/ dr/Linger/). Subjects pressed a button to progress through the sentence region by region. After each sentence, subjects answered a comprehension question about what they had read. The items from this experiment were intermixed with 82 items from other experiments, randomized for each subject. For half of the subjects, a simple arithmetic question (addition or subtraction) intervened between the completion of reading the sentence and the comprehension question. This manipulation was included to prevent subjects from using an auditory rehearsal strategy in order to answer the comprehension questions, and therefore to cause them to fully comprehend the sentence as they read it.

3.3.1.2 Results

3.3.1.2.1 Data Analysis One item was removed from all analyses due to a coding error. Prior to statistical analyses, the data were trimmed to remove outliers. Extreme data points above 6000ms were removed from the data. Then, observations above or below three standard deviations of the subject by region mean were removed, for a total loss of 1.9% of data points (126/6624 observations in total). The reliability of differences was tested with linear mixed-effects models using the lme4 package in R (Bates, 2005; Baayen et al., 2008). The models reported here included fixed effects of Gap Type (subject or object) and Than-phrase Position (base vs. extraposed). The models also included random intercepts and random slopes for Gap Type, Than-phrase Position and their interaction (a maximal random-effects structure, as recommended by Barr et al. (in press)). I will consider t-values of 2 or greater to be significant, and those that above 1.90 to be marginally significant. All factors were centered prior to analysis. All lmer tables are reported in the appendix. Including the presence of an arithmetic question as a factor did not improve model fit (based on model comparisons using the anova() function in R). I will therefore leave this factor out of the models reported in the main results section, but return to it before the discussion.

3.3.1.2.2 Reading Times The mean reading times for each region are shown in Table 3.1 and shown graphically in Figure 3.1. On the sentence-initial region, there were no significant effects of Gap Type or Than-phrase Position (ts < 1.2). This is expected given that all conditions have the same material in this region. On the *than*-phrase region, which came second in the *base* conditions and third in the *extraposed* conditions, there was a significant effect of Gap Type such that subject gaps were associated with a 71 ms increase in reading times over object gaps (Estimate = 71.65, SE = 33.53, t = 2.14). Figure 3.1 shows that the penalty for subject gaps was mainly for those comparative clauses in base position. However, while there was a numerical trend toward an interaction between Gap Type and Than-phrase Position, this interaction did not reach significance (Estimate = -103.44,

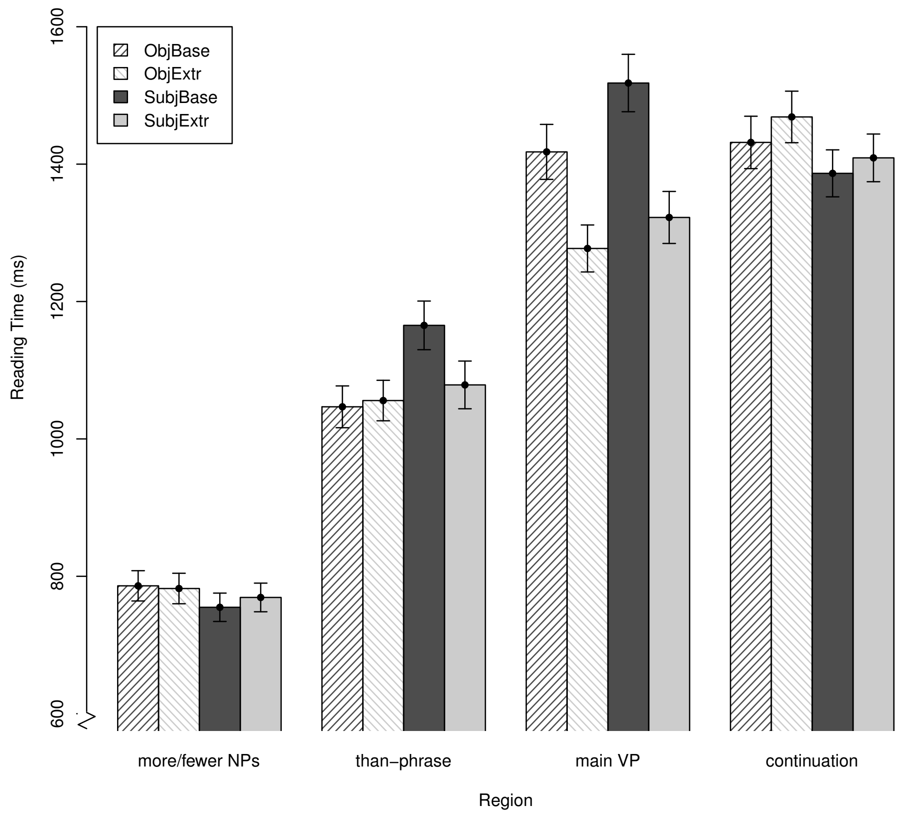


Figure 3.1. Mean reading times by region, Experiment 2.

Note: bars indicate standard errors of the mean. For base position conditions, the comparative clause preceded the main VP, and vice-versa for extraposed conditions.

SE = 81.03, *t* = -1.28). On the main VP region, there was a significant effect of Gap Type such that subject gaps were overall associated with longer reading times than object gaps (Estimate = 71.08, SE = 35.08, *t* = 2.03). For the conditions with extraposed *than*-phrases, any advantage for object gaps must be a spurious finding, as there is no difference between the two gap conditions at the point of the main VP. There was also as an effect of Than-phrase Position on the main VP region, such that main VPs that preceded the *than*-phrase were read on average 169ms faster than those that followed the *than*-phrase (Estimate = -158.64, SE = 38.21, *t* = -4.15). There was no significant interaction between the two factors on the main VP region. There were no significant differences on reading times on the final region of the sentence (all *t*s < 1.3).

Region	Object Extraction Base	Object Extraction Extraposed	Subject Extraction Base	Subject Extraction Extraposed
more NPs	786	782	754	769
than-phrase	1047	1056	1165	1079
main VP	1418	1277	1518	1322
continuation	1432	1469	1387	1409

Table 3.1. Mean reading times, Experiment 2.

	Base Position	Extraposed Position
Subject Gap	2661	2400
Object Gap	2466	2308

Table 3.2. Mean reading times for the summed than-phrase and main VP regions.

Note: these means are not equal to the sums of the *than*-phrase and main VP cells in the previous table. This is because if one of the two values to be summed was removed as an outlier, no value for that trial was included in the summed measure.

In this experiment, the comparative clause varied in its position between the base and extraposed conditions. In order to rule out any effect based solely on linear position in the sentence (for example, subjects speeding up in their reading over the course of a trial), the sum of reading times for the *than*-phrase and main VP regions was analysed as one measure, forming a region that covered the second and third presentation regions of the sentence for all conditions. Mean reading times for this summed measure are shown in Table 3.2. Analysis of this region showed a significant effect of Gap Type (Estimate = 141.10, SE = 51.26, t = 2.75) and a significant effect of Than-phrase position (Estimate = -182.79, SE = 62.56, t = -2.92). As with the *than*-phrase region, the subject gap, base position condition had the numerically longest reading times. However, the interaction did not reach significance (Estimate = -135.40, SE = 115.56, t = -1.17).

3.3.1.2.3 Arithmetic manipulation Although the inclusion of the arithmetic question in the experimental procedure was not significant on the critical *than*-phrase region and did not improve model fit, it is worthwhile noting that on numerically, the interaction was larger for those subjects who did complete an arithmetic question following the sentence and before the comprehension question than those who did not. The main VP also showed numerically more inflated reading times for the subject gap, base position condition, although the arithmetic manipulation was nonsignificant on this region as well. Reading times separated by arithmetic condition are shown in Figure 3.2.

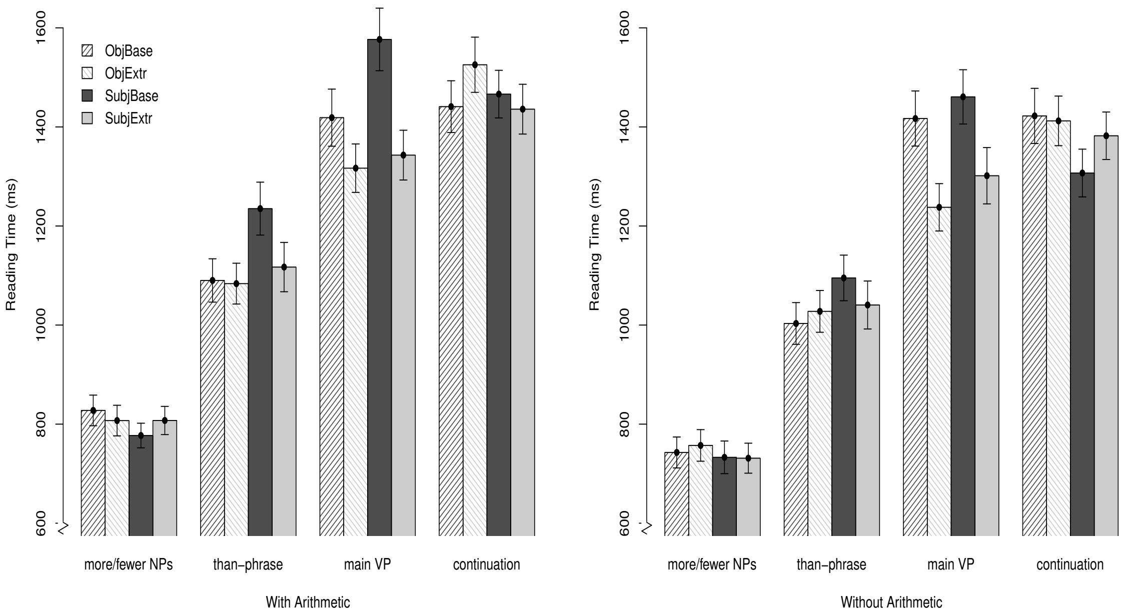


Figure 3.2. Mean reading times, Experiment 2 for arithmetic question (left) and no arithmetic question (right) conditions.

3.3.1.2.4 Comprehension Accuracy The overall accuracy rate for comprehension questions was high. Table 3.3 shows the mean comprehension accuracy by condition. A mixed-effect logistic regression model with fixed effects of Gap Type, Than-phrase Position and Arithmetic Manipulation and their interactions, and random slopes for each factor (included without their interactions, as models with the interactions in the random effects structure did not converge) showed a significant three-way interaction between the factors such that the largest difference between conditions was between the Gap Types for the base position *than*-phrases when the math questions were present (Estimate = -4.46, SE = 1.67, z = -2.67, $p < .01$). The results also showed a significant interaction of Than-phrase Position with Math Manipulation (Estimate = -3.67, SE = 1.09, z = -3.36, $p < .001$) and an overall effect of Than-phrase Position. (Estimate = -1.50, SE = 0.69, z = -2.17, $p < 0.05$). No other effects were significant. While there were some differences in comprehension between the conditions, subjects answered questions about all conditions with above 90% accuracy, leading us to believe that they were paying attention to the stimuli and motivated to perform well in the experiment. The effects could indicate that the presence of a math question could require subjects

	Object Extraction		Subject Extraction	
	Base	Extraposed	Base	Extraposed
Without arithmetic questions	97.2	96.8	94.4	96.8
With arithmetic questions	96.3	97.2	98.6	95.8

Table 3.3. Comprehension question accuracy rates (% correct) by condition, Experiment 2.

to pay additional attention to the experiment and that this attentional increase aided subjects in answering questions about the subject gap, base position condition - the most difficult by reading time measures.

3.3.1.3 Discussion

The results of Experiment 2 show that comparative clauses with object gaps have shorter reading times than those with subject gaps. The effect of gap position was significant on both the comparative clause region itself and the main VP. While the interaction between the position of the comparative clause and the extraction type did not reach significance, the trend toward an interaction suggests that the greatest penalty for subject gaps is observed in base position. This is a new empirical observation that a theory of extraction from comparative clauses must account for. Reading times for the comparative clause and main VP regions added together show a cost for sentences with comparative clauses in base position. The advantage for extraposed comparative clauses is another point of divergence between comparative clauses and the literature on relative clauses. Extraposed relative clauses are generally dispreferred (as shown by elevated reading times) unless linguistic cues lead readers to expect them (Levy et al., 2012).

While Experiment 2 confirms the intuitive judgments regarding extraction from comparative clauses, it has two limitations with respect to the comparison of comparative clauses to relative clauses. First, personal pronouns were used as non-extracted arguments in the comparative clauses. As mentioned in the description of materials, these pronouns were chosen to eliminate a potential garden path effect (see Chapter 2 for an examination of such garden path effects in comparatives). However, as mentioned earlier in the chapter, Reali and Christiansen (2007) found that relative clauses with personal pronouns did not show the canonical cost for object gaps. They performed a corpus search that showed relatively more object relative clauses than subject relatives when the overt noun in the relative clause was a first, second or third person pronoun. Three self-paced reading experiments further showed an advantage in reading times for object relatives when the overt noun was a personal pronoun. Both the corpus pattern and the reading time pattern reversed when the relative clause contained an overt impersonal pronoun *it*. It is therefore possible that the comparatives in Experiment 2 were merely following the pattern shown by Reali and Christiansen, and that with non-pronominal DPs, object comparative clauses would be associated with more difficulty than subject comparative clauses. Second, Experiment 2 did not test include relative clause conditions, so there may have been other idiosyncrasies beyond the use of pronouns in the materials that were responsible for the pattern, and would have produced an unusual pattern for relative clauses as well. These two concerns are addressed by Experiment 3. In Experiment 3, definite DPs replaced the pronouns in the comparative clauses. Instead of including both base position and extraposed comparative clauses, Experiment 2 focused on comparatives in base position, comparing these directly to relative clauses in the corresponding position.

3.3.2 Experiment 3

Experiment 3 examined reading times for comparative clauses in base position and corresponding relative clauses. The fist and second-person pronouns were replaced with definite DPs in order to test whether the results hold across DP types.

3.3.2.1 Method

3.3.2.1.1 Materials 24 item sets like (146) were constructed by modifying the sentence frames from Experiment 2. Two conditions were comparatives with comparative clauses in base position (a-b), and two were relative clauses (c-d). This manipulation was crossed with gap position (object gap in a,c ; subject gap in b,d) in the comparative or relative clause.

(146) a. Object Extraction, Comparative

More friends/ than the shy girl talked to/ were at the party,/ according to the pictures on Facebook.

b. Subject Extraction, Comparative

More friends/ than talked to the shy girl/ were at the party,/ according to the pictures on Facebook.

c. Object Extraction, Relative Clause

The friends/ that the shy girl talked to/ were at the party,/ according to the pictures on Facebook.

d. Subject Extraction, Relative Clause

The friends/ that talked to the shy girl/ were at the party,/ according to the pictures on Facebook.

3.3.2.1.2 Procedure Forty-four UMass undergraduates participated for psychology course credit. The experiment was presented using Linger software (Rohde, 2003). Subjects pressed a button to progress through the sentence region by region. After each sentence, subjects were asked to rate the naturalness of the sentence on a scale from 1(totally unnatural) to 7 (totally natural).

3.3.2.2 Results

3.3.2.2.1 Statistical Analysis Prior to statistical analyses, the data were trimmed to remove outliers. Observations above or below three standard deviations of the subject/region mean were removed, for a total loss of 1.5% of data points (67/4224 observations). Model parameters can be found in Appendix C.

3.3.2.2.2 Reading Times The mean reading times per region of presentation are shown in Table 1. Reading times on the initial region showed longer reading times for the comparative conditions than for the relative clause conditions (which had a definite DP in this region) (Estimate = -130.49, SE = 21.62, t = -6.04). No other effects were significant (ts < 1). On the critical region (the comparative or relative clause), there was an interaction such that comparative clauses with subject gaps had longer reading times than those with object gaps, while the reverse was true for relative clauses (Estimate = -701.47, SE = 132.48, t = -5.30). The overall effect of clause type was also significant with a penalty for comparatives over relatives (Estimate = -470.09, SE = 57.96, t = -8.11). The main VP region showed a marginal effect of clause type (Estimate = -93.92, SE = 48.77, t = -1.93) and gap position (Estimate = -149.29, SE = 49.89, t = -2.99), but no interaction. On this region, the object-extracted clauses had longer reading times for both comparatives and relative clause sentences. The final region of the sentence showed no significant effects.

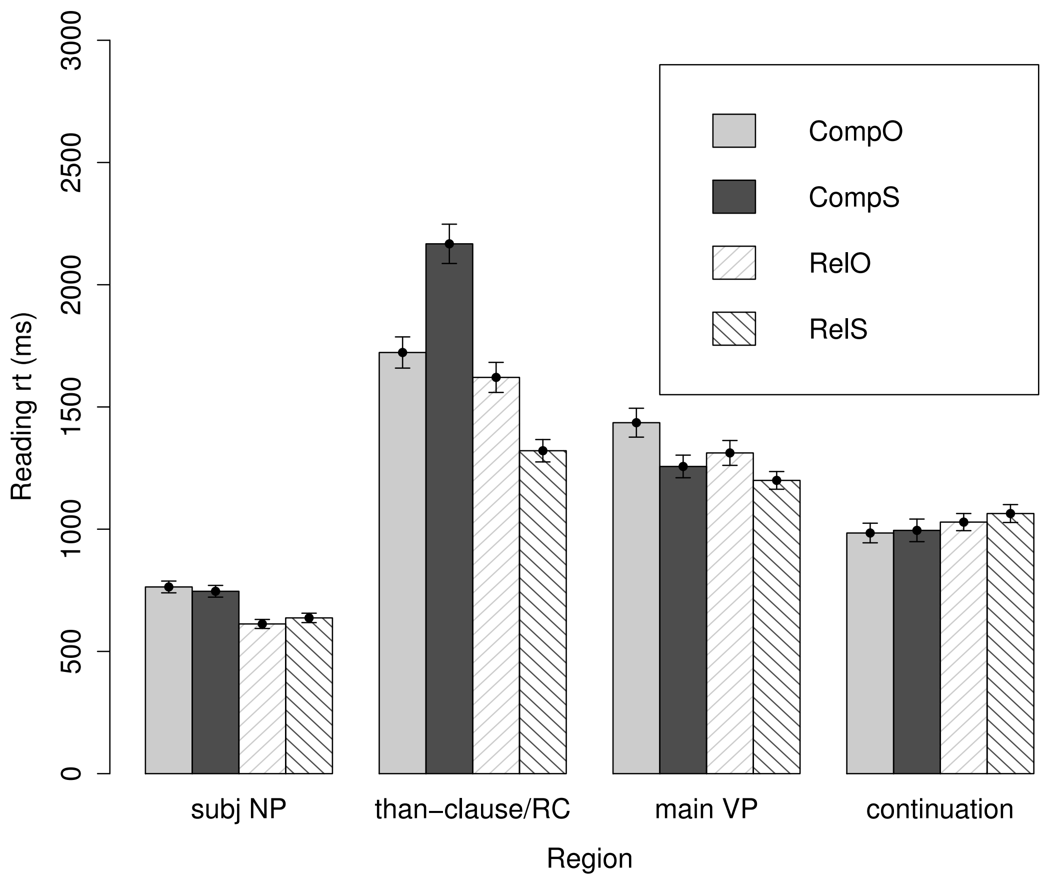


Figure 3.3. Mean reading times by region, Experiment 3.

(Note: bars indicate standard error of the mean.)

Region	Comparatives Obj Extraction	Subj Extraction	Relative Clauses Obj Extraction	Subj Extraction
Initial region	764	746	612	637
Comparative/relative clause	1723	2167	1621	1321
main VP	1436	1257	1312	1200
continuation	984	995	1029	1064

Table 3.4. Mean reading times per condition per region, Experiment 3.

3.3.2.2.3 Naturalness ratings Means for the naturalness rating task for Experiment 2 are shown in Table 3.5. These means showed an interaction such that comparatives with subject gaps were rated lower than comparatives with object gaps, while numerically the opposite was true for relative clauses (Estimate = 0.894, SE = .230 , t = 3.89). Comparatives were generally rated as less natural than relative clauses as well (Estimate = 1.77, SE = 0.192, t = 9.26). The effect of gap position was significant, although the conditional means show that the effect was driven by the difference between the comparative conditions (Estimate = -0.265 ,SE = .117 , t = -2.26).

Region	Comparatives Obj-gap	Subj-gap	Relative Clauses Obj-gap	Subj-gap
Rating	3.69	2.97	5.01	5.19

Table 3.5. Mean naturalness ratings, Experiment 3.

3.3.2.3 Discussion

The results of Experiment 2 show that the subject gap penalty found in Experiment 1 was not an artifact of the use of personal pronouns or other idiosyncrasies in the construction of materials. Experiment 2 directly compared comparatives to relative clauses, which showed the expected penalty for object relative clauses as compared to subject relatives.

3.4 Summary of the empirical pattern and the remaining problem

3.4.1 Summary of Experiments 2 and 3

Together, the results of Experiments 2 and 3 show that in comparative clauses, there is a cost to processing and degraded acceptability for subject gaps as compared to object gaps (with a possible exception of those comparative clauses in extraposed position). The pattern of processing is unlike the general pattern found in the research on relative clause processing, where object gaps show a penalty as compared to subject gaps. Subject gaps remained difficult as compared to object gaps in comparative clauses regardless of whether the spelled-out argument was a pronoun or definite DP, unlike the results in the literature on relative clauses (e.g., Reali and Christiansen, 2007).

Experiment 3 provided further evidence to be used in determining the nature of the difficulty with subject gaps in comparatives by including naturalness rating questions after each self-paced reading trial. Comparatives overall were rated as less natural than relative clauses, and subject gaps in comparatives were rated as less natural than any other condition (while numerically subject gaps in relative clauses were rated as more natural than object gaps). In the relative clause processing literature, it is common for experimenters to rule out confounds based on plausibility by ensuring that there are not large differences between conditions in similar naturalness rating studies (e.g., Gibson et al., 2005). However, there are several things that could be meant by 'naturalness.' In our study, we did not equate naturalness to real-world plausibility, but rather simply asked how natural a sentence was to the reader. Therefore, our subjects could have been taking a number of factors into account, including plausibility, grammatical acceptability or complexity. Because the relative clause examples were rated with similar naturalness, it is unlikely that the difference between subject and object gaps in comparatives is due to the plausibility of the associate of comparison (the filler) as a subject or as an object in general. The difference in naturalness between the gap types in comparatives is therefore likely due to whatever underlying factors create the processing difficulty (and naturalness penalty) for subject gaps.

3.4.2 Relative clauses vs. comparative clauses

In Section 3.2, I provided a brief summary of the theories that have been proposed to account for the processing of gaps in relative clauses. In Section 3.3, I presented experimental results showing that while there is a robust object gap penalty for relative clauses in English, comparative clauses show a subject gap penalty. None of the theories described in Section 3.2 straightforwardly predict the pattern of results found with comparative clauses. Both linear and structural distance accounts would predict the same pattern between subject and object gaps for relative and comparative clauses, as would the perspective shift account. Further research needs to be carried out to determine the relative frequencies of subject and object gaps in comparative clauses in order to determine whether a frequency-based account could be proposed for the data in Experiments 2 and 3. It is highly plausible that object gaps are more frequently produced and heard/read than subject gaps in comparative clauses[4], but that would still leave open the question of *why* people produce fewer subject gaps, given the facts about the superficially similar relative clauses. One might also expect that in order to be the sole cause of the effect on naturalness ratings found in Experiment 2 (in comparison to the smaller effect for relative clauses), the frequency difference between subject and object comparative clauses would have to be extreme. In order to support a frequency and semantic indeterminacy-based account like that of Gennari and MacDonald (2008), one option would be to ask whether controlling for some factor, such as the animacy of the associate of comparison for example, could both eliminate the relative frequency asymmetry and mitigate the processing penalty for subject comparative clauses. One place to look for such an elimination might be comparative clauses with a passive verb phrase. While there is no experimental data as of yet to support this claim, intuitively examples like (147) seem to be less costly than comparative clauses with active subject gaps.

(147) More boys than __ were invited came to the party.

We have similarly little information about reader or listener expectations with regard to the discourse status of NP/DPs within comparative clauses. As with frequency, further corpus study

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[4]A search of the tagged Brown, Switchboard and Wall Street Journal corpora of the Penn Treebank was performed using Tgrep2 (Rohde, 2001) showed that subject gaps in comparatives are very rare. The search revealed a very small number of clausal complements to *than* that began with a phonologically null subject. Of the 40 instances found, 9 were not comparative uses of *than*, but constructions using 'rather than' or 'other than'. Another 8 were of the type where the comparative clause included only a past participle of a verb taking a clausal complement, such as (1).

(1) Also, the premiums paid by the U.S. government on a purchase of copper for the U.S. Mint were **lower than expected**....

There were only 7 instances of attributive comparatives with overt associates of comparison, the most similar group to the experimental items in the studies to be reported in this chapter. Unlike the experimental items, these were all in object position and all had inanimate associates of comparison, as shown in (2) and (3).

(2) The len's [sic] foldability enables it to be inserted in **smaller incisions than are now possible for cataract surgery**...

(3) It does **a few more things, uh, than had been available before.**

The number of *than*-clauses with an overt subject was far greater, with 348 unique tokens. However, these include many examples that are not simply comparative clauses with object gaps; they include cases of ellipsis and other conjunction reduction operations.

would be required to know whether the status of these embedded NP/DPs as discourse old or new, or topic or non-topic, has an effect on their processing.

The rest of this chapter, and all of Chapter 4, will focus on the question of why the comparative clause/relative clause asymmetry exists, and further data will be presented to aid in the choice between possible accounts. In this chapter, I will present an account that is present in the literature from Bhatt and Takahashi (2011b) based on the resolution of Focus in comparative clauses, and show that this account does not predict the full pattern of data. I will then consider a processing-based account of the asymmetry, and test the predictions of this account outside of the domain of comparatives.

3.4.3 Focus resolution and comparative clauses

One previous account of the difficulty with subject gaps comes from Bhatt and Takahashi (2011b). In their recent review of Lechner (2004), Bhatt and Takahashi (2011b) propose that the subject gap penalty could be due to a difficulty resolving the placement of focus in comparative clauses. A fully worked out account was clearly beyond the scope of the review, and so Bhatt and Takahashi do not specify whether they expect their constraint to be specified in the grammar, or to apply during on-line processing. Bhatt and Takahashi's claim is that there is a penalty for comparative clauses in base position when there is semantic identity (modulo focused elements, as per Rooth, 1992) between comparative clause and main clause. Bhatt and Takahashi claim that when semantic identity between clauses holds, the comparative clause must include a contrastively focused element. Example (148) has semantic identity between the clauses, as illustrated in (149).

(148) More people bought books [than SOLD them].

(149) [d-many people bought books] // [d-many people SOLD them]

Semantic identity between clauses is not problematic for comparative clauses in extraposed position, like that in (148). However, for comparative clauses in base position (as shown in 150) the focus-marked element precedes its matrix clause antecedent. It is this linear order between contrastive focus and antecedent that Bhatt and Takahashi (2011b) claim is costly to acceptability.

(150) ?? More people than SOLD books bought them.

When there is no semantic identity/parallelism between comparative and main clause, there is no required contrastive focus and no precedence restriction holds. Examples (151a) and (151c) show that base and extraposed positions are both acceptable.

(151) a. More people invited us [than we invited].

b. [d-many people invited us] $\neq$ [we invited d-many people]

c. More people [than we invited] invited us.

The parallelism approach predicts the subject/object gap asymmetry in comparative clauses for those comparatives in subject position, because in subject position *only* comparative clauses with subject gaps can be parallel to the matrix clause.

The focus resolution account of the subject gap penalty leaves some open questions. The first question is the strictness of semantic parallelism between clauses. While subject gaps in sentences like (150) are difficult, Experiments 2 and 3 showed difficulty for subject gaps even when a strict version of semantic identity modulo focused elements would not hold. Therefore, in order to account for the empirical data, the definition of parallelism would have to be weakened.

Next, there is the question of the level of application of the constraint against a contrastively focused element preceding its antecedent in the main clause. It is unclear whether there is a universal constraint against a contrastively focused element in a subordinate clause preceding its antecedent in the matrix clause (see example 153 as compared to 152).

(152) I like PEANUT BUTTER moreso than JAM.

(153) Moreso than PEANUT BUTTER, I like JAM.

The judgments for examples like (150) also vary between theoretical accounts of comparatives. While Osborne (2009) would rule out such examples, Lechner (2004) treats these as grammatical and makes no reference to them being degraded. It is therefore unclear whether or not it is desirable to place Bhatt and Takahashi (2011b)'s constraint into our grammatical theory of comparatives. The alternative would be to propose that the difficulty with examples like (150) is due to comprehenders' inability to correctly predict the placement of focus during on-line processing without already having encountered the relevant part of the matrix clause. Such an account would eliminate the need to potentially stipulate constraints to grammatical theory, and would provide an explanation for the on-line processing effects reported in this chapter. A final problem for a focus resolution account is that subject gaps in comparative clauses appear to be degraded in object position as well as subject position. Focus resolution would not make this prediction, as comparative clauses in object position follow the critical material in the matrix clause whether they have an object gap (154a) or a subject gap (155a).

(154) a. The newspaper mentioned more people than the police arrested __.

b. [The newspaper arrested d-many people] // [The police arrested d-many people]

(155) a. ?? The newspaper mentioned more people than __ broke the law.

b. [The newspaper arrested d-many people] // [d-many people broke the law]

In order to confirm this judgment, a pilot study was conducted in which subject and object gaps in comparative clauses were compared for object position. This study is presented in the following section.

3.5 Subject comparative clauses in object position

So far in this chapter, I have shown that there is a penalty for subject gaps in comparative clauses when the comparative is in subject position. However, intuitions suggest that subject gaps in object-position comparatives can be degraded as well. Example (156a) which is degraded with respect to its object-extracted counterpart (156b). Example (156c), has comparative in object position, and the subject gap still creates degraded acceptability as compared to an indirect object gap (156d).

(156) (judgments mine)

a. ?More kids than __ played basketball played soccer.

b. More kids played soccer than __ played basketball.

c. ??I met more kids than __ played basketball.

d. I met more kids than you played basketball with __.

If we are to find a unified account of the subject-position and object-position penalties for subject gaps, then the degraded status of (156c) provides further evidence against an account based on focus resolution. In object position, there is no parallelism between the matrix and comparative clause,

Condition	Mean Rating (*standard error*)
Object Gap	5.49 (.18)
Subject Gap	3.06 (.22)

Table 3.6. Mean ratings per condition, Experiment 4.

Note: sentences were rated on a scale from 1 (completely unacceptable) to 7 (completely acceptable).

and further the comparative clause cannot precede the main VP. However, an island account would predict that comparative clauses in general, no matter what position they are associated with, should show a subject gap penalty. The processing bottleneck account presented in Section 3.6 could also predict the penalty for (156c), because readers could have an expectation for a bare NP following *than* that must then be revised in order to process the clause.

In order to confirm the intuition that subject gaps in comparative clauses are indeed degraded as compared to object gaps in object position, a pilot experiment was carried out to collect ratings from native speakers of English.

3.5.1 Pilot Experiment 4

3.5.1.0.1 Method Eight sets of sentences were devised in object gap and subject gap versions, as shown in (157). The items were counterbalanced across two lists and interspersed with items from other experiments.

(157) a. *Object Gap*: I met more scholars than Susan contacted before the conference.

b. *Subject Gap*: I met more scholars than contacted Susan before the conference.

Twenty undergraduate students in introductory linguistics courses at the University of Massachusetts Amherst participated in the experiment for course credit. Subjects rated each sentence on a scale from 1 (completely unacceptable) to 7 (completely acceptable).

3.5.1.0.2 Results The results of the experiment showed that indeed, sentences in the subject gap condition (157b) were rated as less acceptable than the object gap comparatives (157a) (Estimate = -2.43, SE = .345, t = -7.04).

3.5.1.0.3 Discussion The results of the pilot study show that, indeed, there is a subject gap penalty for comparative clauses in object position. This finding is consistent with either the subject island or processing bottleneck accounts, but not the focus resolution account.

3.6 A Processing Account

3.6.1 A processing bottleneck

This section will present a possible alternative account to the Focus Resolution account that does not rely on any special semantic or functional properties of comparatives, but is rather based purely on a possible spike in processing complexity in subject gap comparative clauses. As seen in Chapter 2, readers have particular expectations about the phrase structure of upcoming material in comparatives, namely that confronted with a string of the form *more NP than*, they expect that *than* will have an NP complement as opposed to a clause. In all comparative clauses in this kind of sentential context, the parser must deal with the disconfirmation of this expectation. When a comparative clause has a subject gap, the parser must not only revise its structural expectation, but also posit and fill a gap at the same point in the sentence. This requirement differs from object-gap comparative clauses, where (if no garden path occurs), the subject of the relative clause provides the disambiguating information toward a comparative clause interpretation, and a gap does not have to be posited until at least one word (the comparative clause predicate) downstream. The difference in the timecourse of operations between subject and object gaps is shown in Figure 3.4.

It is possible that revising structural expectations and positing and filling a gap position at the same point in processing incurs a processing cost that is greater than the additive cost of each operation in isolation. Under such a hypothesis, receiving a verb as input following *than* would cause a 'bottleneck' in processing.

(158) *Processing Bottleneck Hypothesis:* Retroactively positing and filling a gap at a point of revision causes processing complexity beyond what is expected from the sum of those two operations.

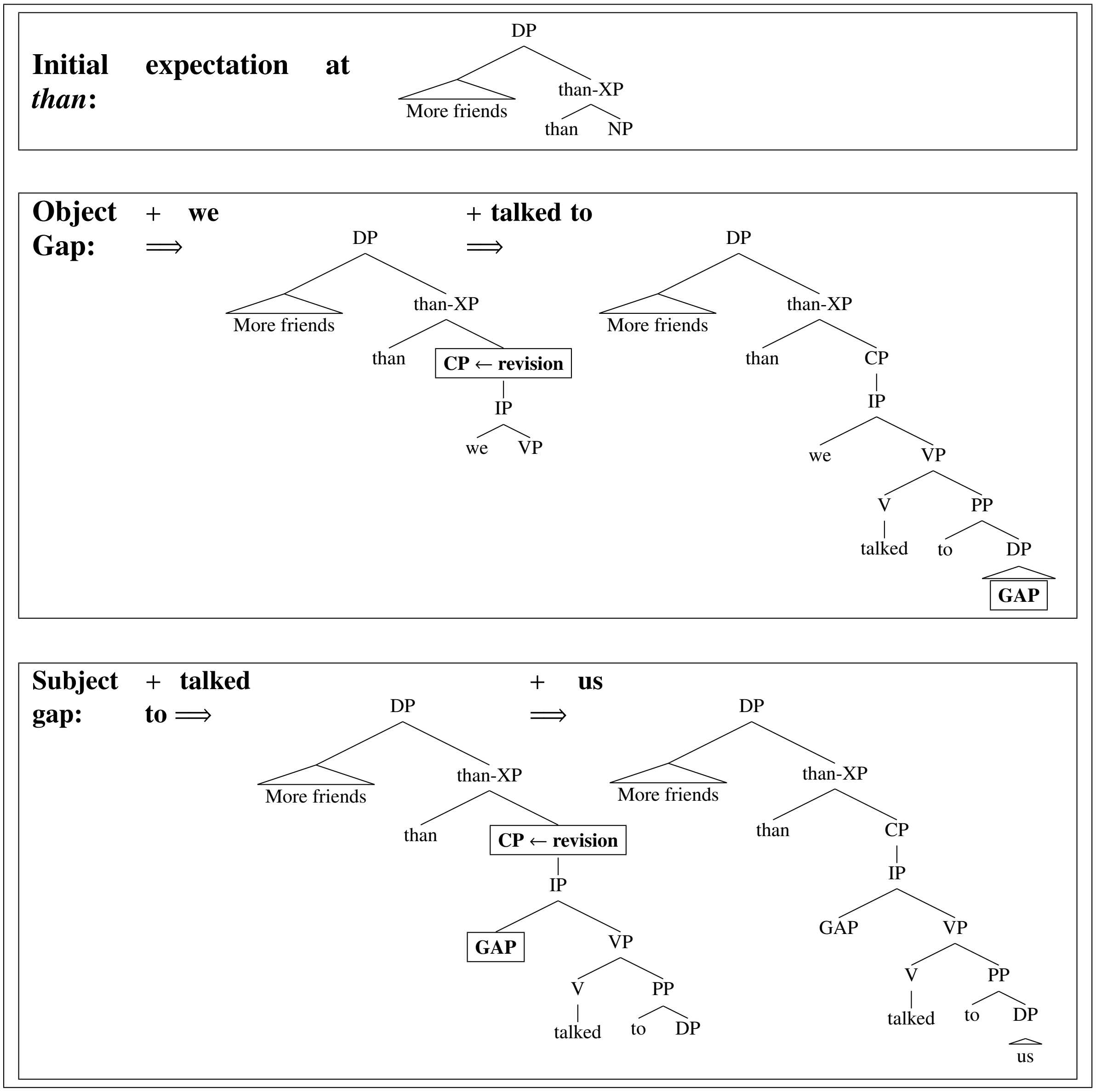


Figure 3.4. Schematic of the integration of words into the structure in object and subject gap comparative clauses.

Note: in the object gap case, the revision toward a clausal complement to *than* and the filling of the gap occur at different points in processing. In the subject gap case, these two operations both must be performed at the same point in the input.

To directly test the Processing Bottleneck Hypothesis, an experiment was carried out to determine whether a gap position at a reanalysis point in a non-comparative structure like (159) caused a similar super-additive cost in processing.[5]

(159) a. The detective interrogated the man he understood the police officer threatened __.

b. The detective interrogated the man he understood __ threatened the police officer.

The examples in (159) have a verb, *understood*, that is biased toward taking a DP direct object over a clausal complement (as reported by Gahl et al. (2004b)). However, the verb is used with a clausal complement in (159), creating an embedded clause within a relative clause. The embedded clause has a gap either in subject or in object position. This structure is a good test of the bottleneck hypothesis because it involves an unfulfilled expectation for a DP object after the verb, and also a gap that either appears several words later (159a) or immediately after the verb in question (159b). If it is true that postulating a gap while recovering from an unfulfilled syntactic expectation causes a spike in processing difficulty, then (159b) should incur processing difficulty on the embedded clause within the relative as compared to (159a).

3.6.2 Experiment 5

3.6.2.1 Materials and Procedure

3.6.2.1.1 Materials Twenty-four item sets like (160) were created (160a) shows the presentation regions). Each sentence had a relative clause on the direct object of a transitive verb (e.g., *interrogated*), and the relative clause itself contained an embedded clause. The experiment varied the extraction type of the relative clause was varied between object extraction (160a, c) and subject extraction (160b, d). In addition, the bias of the main verb in the relative clause was either toward a DP complement (e.g., *understand*) vs. a CP-complement (e.g., *believe*). Verbs were selected for each bias condition based on norms from Gahl et al. (2004b,a), compiled from the TASA corpus of approximately 17 million words and the Brown Corpus of approximately 1 million words. For each verb, scores for proportion of DP (PropDP) and CP (PropCP) complements were calculated. PropDP was calculated by dividing the number of active transitive tokens (including those with par-

[5]The design takes some inspiration from Pickering and Shillcock (1992), which I will return to in the discussion.

ticles) by the total number of tokens for that verb. PropCP of was calculated similarly by dividing the number of tokens with sentential complements by the total number of tokens. Twelve verbs with either relatively high PropDP values of PropCP values were chosen, and each verb was used in two item sets in the experiment. The mean values of PropDP and PropCP for the verbs used in the experiment are shown in Table 3.7), and the values for each individual verb are shown in the appendix. On average, the difference between the PropCP and PropDP values between the DP-bias verb and the CP-bias verb for any particular experimental item set was 0.38.

	PropDP	PropCP
DP-Bias	.50	.13
CP-Bias	.11	.44

Table 3.7. Mean verb biases, Experiment 5 (based on norms from Gahl et al., 2004b).

(160) a. The detective/ interrogated the man/ he understood /the police officer threatened / because / it was /important /to find out /the truth.

b. The detective interrogated the man he understood threatened the police officer because it was important to find out the truth.

c. The detective interrogated the man he believed the police officer threatened because it was important to find out the truth.

d. The detective interrogated the man he believed threatened the police officer because it was important to find out the truth.

3.6.2.1.2 Procedure Experiment 5 was run in concurrence with Experiment 3. The subjects and procedure were identical, except that comprehension questions were asked in place of naturalness ratings. The comprehension questions had two multiple-choice answers, which subjects answered by pressing a keyboard key.

3.6.3 Results

3.6.3.0.3 Statistical Analysis Prior to statistical analyses, the data were trimmed to remove outliers. Observations above or below three standard deviations of the subject/region mean were removed, for a total loss of 1.9% of data points (147/7920 observations). For this experiment, the LME models with random slopes for the interaction of verb bias with gap type did not converge.

Therefore, models with random intercepts and random slopes for each factor are reported. Model summaries are shown in the Appendix.

3.6.3.0.4 Reading times The mean reading times for all regions are shown in Figure 3. Statistical tests for the regions of the most deeply embedded clause in the relative clause (*the police officer threatened / threatened the police officer*) showed a significant effect of verb bias (Estimate = 174.64, SE = 66.15, t = 2.64), with complements of DP-biased verbs having reading times of 182ms on average longer than the CP-biased verbs. While there was a numerical trend toward an interaction such that the subject-gap, DP-biased condition had the longest reading times, this interaction did not reach significance (Estimate = 147.65, SE = 98.32, t = 1.50). On the following region, where any spillover effects could possibly be observed, conditions with object gaps had longer reading time s than those with subject gaps (Estimate = -77.07, SE = 22.72, t = -3.39), but no other effects reached significance.

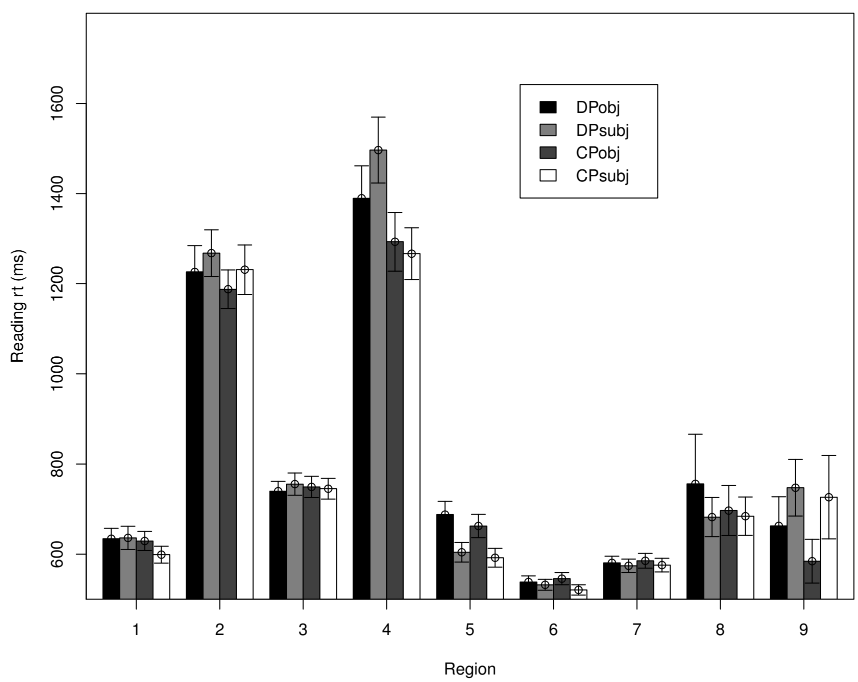


Figure 3.5. Mean reading times by region, Experiment 5

3.6.3.0.5 Comprehension question accuracy One comprehension question was removed from analyses due to an ambiguity. Mean accuracy rates for the remaining comprehension questions

	DP-Bias	CP-Bias
Object Gap	80.6	85.0
Subject Gap	84.2	84.6

Table 3.8. Mean comprehension accuracy, Experiment 5.

are shown in Table 3.8. While numerically the DP-biased, object gap condition had the lowest comprehension rates, in a linear mixed-effects model with random intercepts and slopes for each of the fixed effects (verb bias and extraction type), none of the factors reached significance.

3.6.3.1 Discussion

The results of Experiment 5 are equivocal as to whether positing a gap at a point of unfulfilled phrase structure expectations causes a 'bottleneck' in processing. The critical region showed a numerical trend toward an interaction that would have supported the bottleneck hypothesis, but the interaction was nonsignificant. There are at least two possible explanations for this pattern of results. The first possibility is that there is no special cost of positing a gap while revising phrase structure expectations, which gave rise to a nonsignificant interaction. A second possibility is that there truly is a processing bottleneck, but properties of the experimental design caused a muddy pattern of results. For example, conditions a and c contained object relative clauses, which showed longer reading times on the spillover region. It could be the case that the difficulty associated with processing an object relative inflated reading times on these conditions, leading to a smaller difference between the object relative and the subject relative in the DP-biased condition than would otherwise have been found. Some support for the second possibility comes from Pickering and Shillcock (1992). Pickering and Shillcock used a self-paced reading task to compare subject and object relatives where the gap was in either an embedded or a non-embedded position in the relative clause.

(161) Pickering and Shillcock (1992):1-4

a. The sportsman man who hated Karen was having a bad season. (simple subject relative)
b. The sportsman man who Karen hated was having a bad season. (simple object relative)
c. The sportsman man who you thought hated Karen was having a bad season. (embedded subject relative)

d. The sportsman man who you thought Karen hated was having a bad season. (embedded object relative)

In the embedded conditions, Pickering and Shillcock used the verbs *think*, *swear*, *believe* and *hope*. In the experiment described above, *think* and *swear* and *believe* were included as CP-biased verbs. *Hope* was not included in the Gahl et al. (2004b) norms used to decide verb bias, presumably because it is generally not possible for *hope* to have a DP object.[6] Pickering and Shillcock found that subject relatives were in general easier to process than object relatives, and that embedded relatives were more difficult to process than simple relatives. The advantage for subject relatives with embedded gaps provides further evidence that these have an advantage over embedded object gaps in the base case, and therefore could be taken as support for the hypothesis that a true interaction effect in Experiment 4 was muddied by the general subject-gap advantage.

There is another piece of evidence - one that will be discussed in detail in Chapter 4 - suggesting that the erroneous expectation of a phrasal comparative is not the only reason for the subject gap penalty. If subject gaps in Polish clausal comparatives are degraded, it cannot be because a phrasal comparative was erroneously expected. Polish has two standard markers, *od* for phrasal comparatives and *niż* for clausal comparatives (see Pancheva, 2010; Pancheva and Tomaszewicz, 2010). The presence of *niż* would signal a reader or listener that a clausal complement will follow.

3.7 Accounting for the Subject-Gap Penalty

In this chapter, I have shown that comparative clauses show an unexpected penalty for subject gaps created by comparative deletion as compared to object gaps. However, the accounts discussed here, which I have called the Focus Resolution account (Bhatt and Takahashi, 2011b) and the Processing Bottleneck account, each run into problems with empirical coverage and generalizability, respectively. In Chapter 4, I will examine an explanation based on an underlying grammatical difference between movement operations in comparative and relative clauses. Namely, I will argue that in comparative clauses, subject gaps involve a subject island violation that sets them apart from object gaps.

[6] Unless it is possible to *hope a good hope*, etc.

CHAPTER 4

ISLAND VIOLATIONS AND THE SUBJECT GAP PENALTY

In Chapter 3, I presented data from two experiments that showed a penalty for subject gaps in comparative clauses (e.g., 162a) as compared to object gaps (162b).

(162) a. # More students than __ contacted the professor were likely to fail the class.

b. More students than the professor contacted __ were likely to fail the class.

In addition to this key observation for comparative clauses in base position (which, one might have hypothesized to be the most like relative clauses in their processing behaviour, given their superficial similarity), Experiment 2 showed a numerical trend toward a diminished subject gap penalty for comparative clauses in extraposed position, although the trend did not reach statistical significance. Experiment 4 showed that the subject gap penalty is present for comparative clauses in object position, which would not be predicted under the Focus Resolution account.

Building on insights from Chapter 2, I then presented the hypothesis that perhaps it is the revision of structural parsing expectations, along with simultaneously encountering a gap site, that gives rise to the subject gap penalty. I presented self-paced reading data from a non-comparative structure that failed to show a reliable interaction between the complement bias of a verb used in the sentence with the gap site location (subject or object position in an embedded clause, simultaneous to revision of structure or a few words downstream). These data did not show unequivocal support for the processing bottleneck hypothesis, and therefore having to fill a gap at a point of reanalysis is unlikely to be the sole source of the subject gap penalty.

In this chapter, I will argue that the data presented in Chapter 3, along with new data presented below, best support an account in which subject gaps in comparative clauses involve a subject island violation that gives rise to variably degraded status. This account, which I will call the island violation analysis, finds independent support from a similar argument for phrasal comparatives from Pancheva (2010) and Pancheva and Tomaszewicz (2010). However, the variation in processing difficulty and possibly acceptability for subject gaps in comparative clauses has some seemingly systematic properties, which I suggest are best explained at a level outside of the underlying syntax.

4.1 Syntactic properties of relative and comparative clauses

In addition to the processing penalty for subject gaps in comparative clauses in Experiments 2 and 3 from Chapter 3, Experiment 3 also showed a penalty in naturalness judgments for subject gaps. It is important to keep in mind that these ratings were collected after self-paced reading of the sentence, which may lead to different results than an off-line rating questionnaire where subjects could re-read the entire sentence. Nonetheless, the naturalness judgments (Experiment 3) between gap types in comparative clauses leaves open the possibility that there may be a grammatical difference between subject and object gaps underlying the penalty. In this section I will explore the possibilities for such a grammatical account. Despite the surface similarities between comparative and relative clauses, we know that they differ in their meanings, and therefore in the unspoken material in their grammatical representations. The difference I will focus on here is that comparative clauses contain degrees (and involve abstraction over degrees) whereas relative clauses do not. In this section, I will discuss the similarities and differences between relative clauses and comparatives in syntactic theory in the search for a key difference that could be driving the subject gap penalty. A major theoretical similarity is that both relative clauses and comparative clauses have been subject to raising and matching analyses, which I will discuss in Section 4.1.1. However, in Section 4.1.2, I will show that, with respect to operations like extraposition, differences emerge between relative and comparative clauses.

4.1.1 Raising and Matching

A theory of the structure of relative clauses or comparative clauses must contain a hypothesis about how the head of the relative clause (or the associate of comparison) is linked to the gap in the relative or comparative clause. I will focus here on cases of Comparative Deletion, leaving Comparative Subdeletion until the discussion of Kennedy (2002) in Section 4.2. In each of (163) and (164), the indicated gap must be filled with *people* (in the case of the comparative, the gap corresponds to *d-many people*).

(163) Many people who __ ate burgers drank soda.

(164) More people than __ ate burgers drank soda.

For relative clauses, there have been several proposals for how the gap is associated with its filler in the grammatical representation at the surface syntax and LF levels. These include raising analyses (Vergnaud, 1974), matching analyses (e.g. Lees, 1961), and accounts that propose that both structures are available (Carlson, 1977a; Sauerland, 1998; Bhatt, 2002).[1] The raising analysis proposes that the head of the relative clause moves from the gap position outside of the relative clause, as represented in (165). The matching analysis maintains that relative clause heads are both internal and external. the internal head of the relative clause remains internal to the relative clause, with movement of an operator from the trace position to the periphery of the relative clause, and deletion under identity between the head of the relative and the external relative clause head.

(165) *Raising:* Many people$_j$ [[who/*OP* ~~people~~$_j$]$_i$ t_i ate burgers]

(166) *Matching:* Many people [[who/*OP* ~~people~~]$_i$ t_i ate burgers]

Sauerland (1998) cites an argument from Munn (1994) for the existence of both structures (as well as interpretational differences). The claim is that if raising were the only possible analysis, examples like (167a) should cause a violation of binding principle C (that R-expressions must be free) because the trace position is c-commanded by the subject of the relative clause (*he*) in the same way that it is in (167b). However, under the matching analysis, the R-expression itself does not have a trace within the relative clause.

(167) Sauerland (1998): 49

a. Which is [the picture of John$_i$] that he$_i$ likes __ ?

b. *Which picture of John$_i$ does he$_i$ like __?

However, there is also an argument to be made from binding theory for the raising analysis. Following (Shacter, 1973), Bhatt (2002) notes that the pattern of acceptability between (168b) and (168a) is predicted under the raising analysis, wherein the head of the relative clause originates in the gap position within the relative clause. The reflexive in (168a) is grammatical because its trace is locally bound by *John*, whereas the pronoun in (168b) must not be bound.

[1] I leave out here purely head-external analyses.

(168) a. The opinion of himself$_i$ that John$_i$ has __ is unfavorable.

b. *The opinion of him$_i$ that John$_i$ has __ is unfavorable.

Bhatt (2002) also presents evidence for the raising analysis from adjectival modification. The NP in (169) is ambiguous between a *high* and a *low* reading, paraphrased below the example. In the high reading, *first* modifies John's saying, and in the low reading *first* modifies Tolstoy's writing.

(169) Bhatt (2002): 20

The first book that John said Tolstoy had written

'High' reading: In 1990, John said that Tolstoy had written Anna Karenina; in 1991, John said that Tolstoy had written War and Peace. Hence the NP is Anna Karenina. (I.e., order of saying matters, order of writing is irrelevant.)

'Low' reading: John said that the first book that Tolstoy had written was War and Peace. Hence the NP is War and Peace. (I.e. order of writing matters, order of saying is irrelevant.)

While the full argument is beyond the scope of this chapter, Bhatt (2002) shows that only the raising analysis can fully capture the low reading of (169). Bhatt does not rule out a matching analysis in other environments, and therefore concludes that both structures are possible.

In theory, both the raising and matching analyses can be applied to comparative clauses. Lechner (2001, 2004) argues for a raising analysis, while others (Kennedy, 1999) assume a matching analysis. The major difference between comparative and relative clauses is that while in relative clauses the head must be interpreted only once, the corresponding NP in comparatives that undergo Comparative Deletion must be interpreted both inside and outside of the comparative clause as they are associated with different degree variables - the degrees that are being compared.[2] For example, in (170a), we understand that there are two groups of antelopes: those that were chased by a lion, and those that had a stress-free day. The sentence asserts that the second group is larger in cardinality than the first. This indicates that the gap site and associate of comparison can refer to *different* antelopes. However, by their very function and meaning, relative clauses do not have such an interpretation. The gap site in (170b) must have the same referent as the head of the relative clause, and therefore the sentence is infelicitous (assuming that being chased by a lion is stressful).

[2]Although see Chapter 5 for a reading in which the NPs inside and outside of the comparative clause are not disjoint.

(170) a. More antelopes than lions chased __ had a stress-free day.

b. # The antelopes that lions chased __ had a stress-free day.

In order to maintain a raising analysis for comparative clauses, Lechner (2004) had to posit a special type of movement that allows both ends of a movement operation to be interpreted. Under either type of analysis, the interpretation of the gap site is a critical difference between comparative and relative clauses.

4.1.2 Comparative subordination vs. coordination

Another strong difference between relative clauses and comparatives is in the possible positions of the relative or comparative clause in the linear order of the sentence. Extraposed relative clauses, such as (171b) are attested in spoken and written English, but extraposition comes with a penalty to processing difficulty.

(171) Levy et al. (2012):

a. After the show, a performer who had really impressed the audience came on and everyone went wild with applauses.

b. After the show, a performer came on who had really impressed the audience and everyone went wild with applauses.

Levy et al. (2012) showed that extraposed relative clauses, such as (171b), show an increase in processing difficulty as measured by self-paced reading time over relative clauses that immediately follow their head noun (e.g., 171a). However, this penalty was eliminated when the extraposed relative clause was predicted by cues earlier in the sentence, such as *only those* as a determiner on the head noun in (172b).

(172) Levy et al. (2012): Experiment 3

a. The chairman consulted the executives about the company [who were highly skilled and experienced in the industry.]

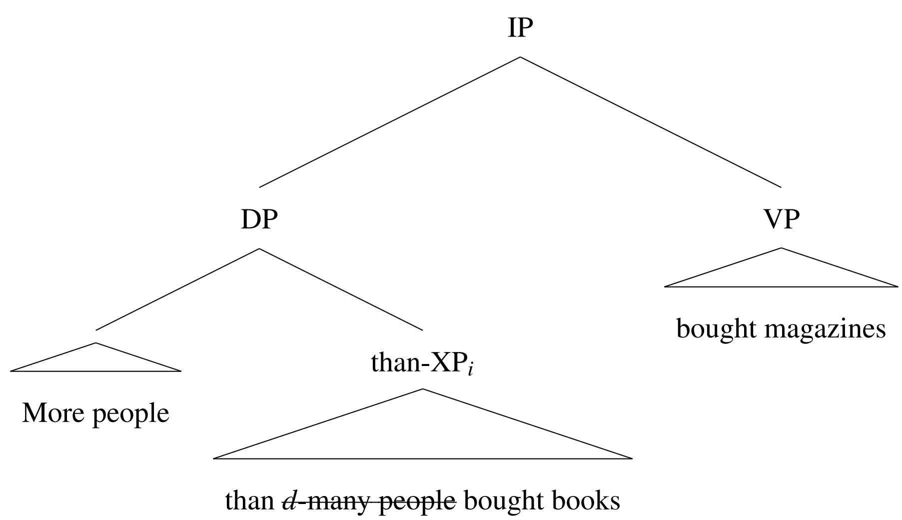
b. The chairman consulted only those executives about the company [who were highly skilled and experienced in the industry.]

Comparative clauses, by contrast, do not show a penalty for extraposition. In fact, extraposed comparative clauses showed numerically shorter reading times in Experiment 2 than those in base position. In order to understand this effect, I will briefly discuss the theoretical differences that have been proposed to exist between comparative clauses in base and extraposed position.

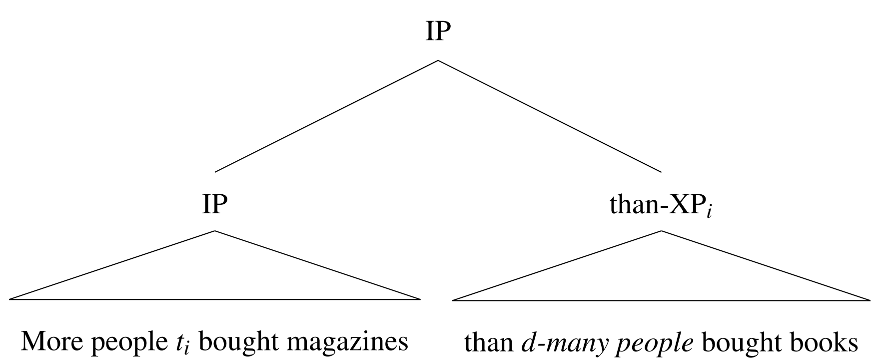
Some theories of the syntactic representation of comparatives (e.g., Lechner, 2001, 2004; Osborne, 2009) distinguish between *comparative subordination* and *comparative coordination* as possible structures for comparatives at the level of surface syntax. Lechner (2004) separates these two structures by extraposition (rightward movement) of the constituent headed by *than*. Under his analysis, the *than*-clause originates subordinate to the matrix clause (and is semantically interpreted there), and may then undergo extraposition to a position coordinated with the matrix clause. A sentence like (173a), for example, would be derived by movement from a structure like (173b) to (173c).

(173) a. More people bought magazines than bought books.

b.



c.



Lechner's CR (Conjunction Reduction)- Hypothesis holds that comparatives undergo the attested reduction operations found in coordination. However, the comparative clause must be extraposed for CR operations (e.g., gapping and right-node raising) to apply. Example (246) shows that when the comparative clause is in rightward-extraposed position, gapping can apply (246b). However if the comparative clause has not undergone extraposition, it may not undergo CR and gapping cannot apply (246d).

(174) Lechner (2001)

a. More people bought magazines [than bought books].

b. More people bought magazines [than $\langle_{gapping}$~~bought~~$\rangle$ books.

c. More people [than bought books] bought magazines .

d. *More people [than $\langle_{gapping}$~~bought~~$\rangle$ books] bought magazines.

The base-position comparative clauses in Experiments 2 and 3 are examples of comparative subordination, while the extraposed comparative clauses in Experiment 2 are examples of comparative coordination. One might expect that the subordinate comparative clauses would behave most like relative clauses, because these are also subordinate. However, this is not the pattern of data we find from either experiment.

Neither the analysis of comparative clauses as raising or matching, nor the possible structural position of the comparative clause (in either subordinate or coordinate position) straightforwardly predict the differences found in Experiments 2 and 3 between relative clauses and comparatives. In the next section, I will present what I believe to be a more successful grammatical account of the data based on subject island violations in comparative clauses.

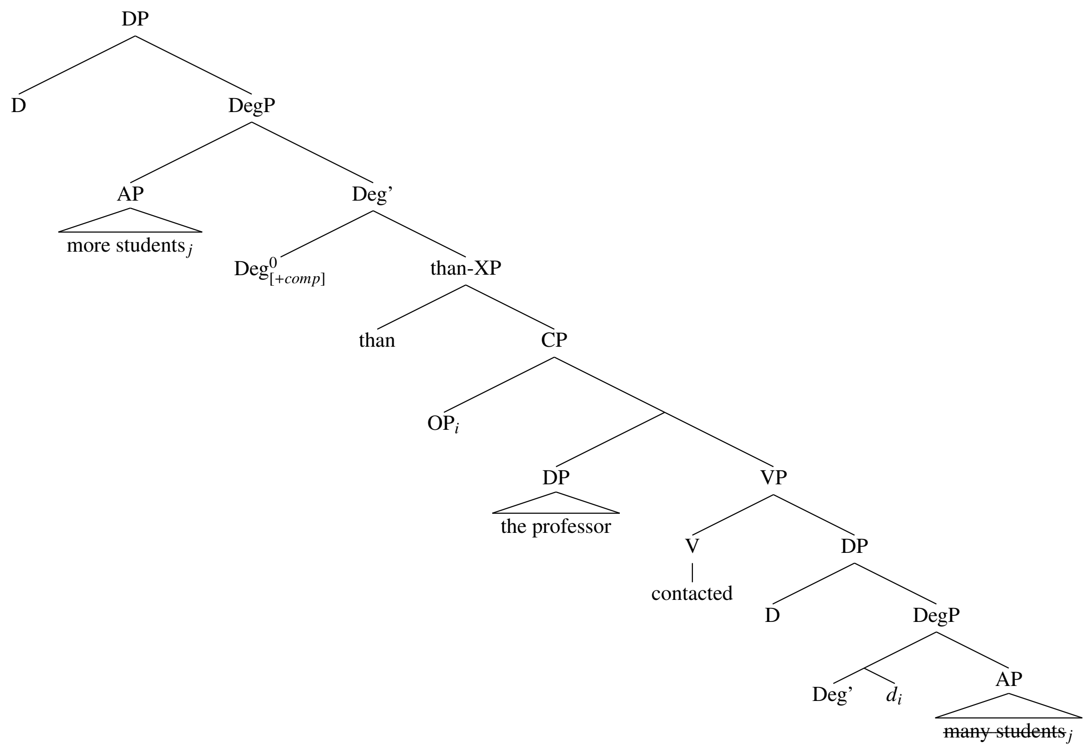
4.2 Movement in comparative clauses

While comparative clauses and relative clauses have both been claimed to involve movement of a wh-operator to the left periphery of the clause, there is a semantic difference between comparatives and relatives that may reveal a difference in the required movement operations. There is some debate in the literature as to what moves in comparative clauses. The structure in (178) for the DP *more students than the professor contacted* shows movement of an operator of type *d* from the lower

DegP to the specifier of the CP complement to *than* (Here, I will use an AP-raising structure close to that of Lechner (2004) for demonstration, but the same should hold for other structures that have been proposed for comparatives (e.g., Kennedy, 1999)). This movement corresponds semantically to lambda-abstraction over a degree variable.

(175) # [$_{DP}$More students than the professor contacted __] were likely to fail the class.

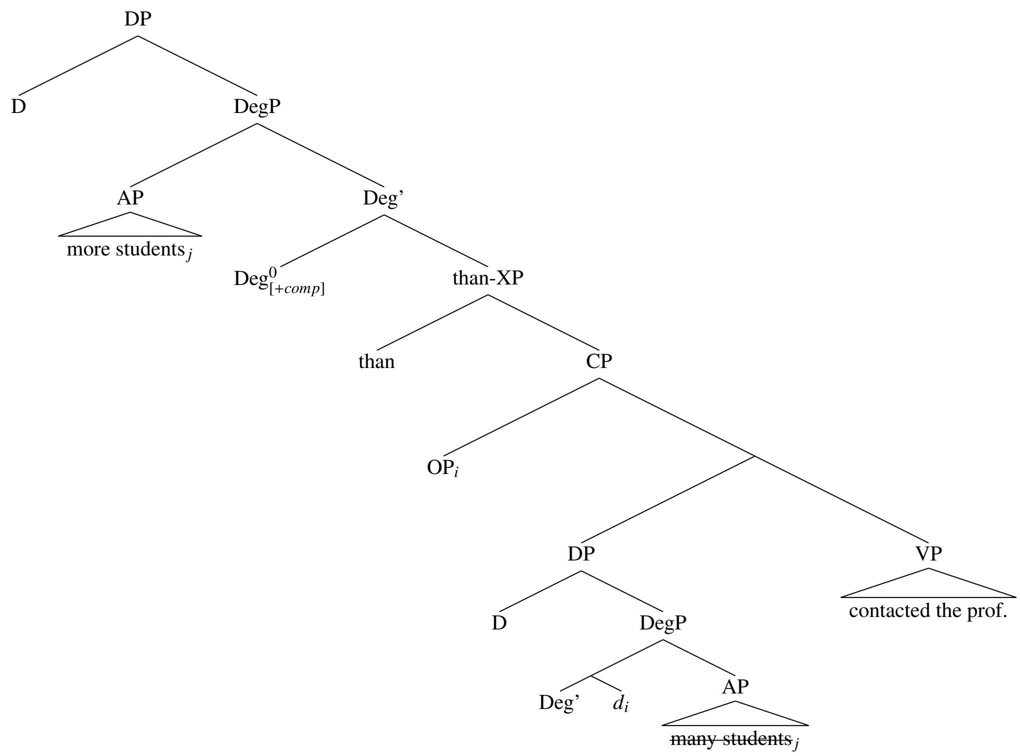
(176)



In the corresponding subject gap case, shown in (177), the movement operation that moves *d* out of DegP is an instance of movement out of a subject, creating a subject island violation. This violation is shown in (178).

(177) # [$_{DP}$More students than __ contacted the professor] were likely to fail the class.

(178) Subject island violation:



Kennedy (2000, 2002) alternatively proposes that it is not merely the degree term that moves, but rather the entire *compared constitutent* (here, the lower DegP). Kennedy argues that this movement applies overtly when the compared constituent is identical to the associate of comparison, as in (178), and deletes under identity with the associate giving rise to Comparative Deletion. This movement is shown in (179).[3]

(179) More students than [$_{CP}$ [~~$_{DP}$ d-many students~~]$_i$ t_i contacted the professor].

Kennedy motivates this analysis by showing that Comparative Deletion acts like *wh*-movement, another instance of overt movement in English, in a number of respects (following Ross, 1967; Bresnan, 1975). Gaps in comparative clauses cannot be inside an island, for example a complex NP island, as shown in (180). In addition, CD creates that-trace effects in the same way that wh-movement does (181b) and licenses parasitic gaps (182).

(180) Complex NP island:

[3] In the case of subcomparatives (Comparative Subdeletion), movement of the compared constituent is argued to be an instance of covert movement.

a. *Which scoring titles is Dennis a guy who has?

b. Kennedy (2002): 9a

*Michael has more scoring titles than Dennis is a guy who has.

(181) That-trace effects

a. Which books did the editor say (*that) would be published?

b. Kennedy (2000):16a

More books were published than the editor said (*that) would be.

(182) Parasitic gaps:

a. Which books did you keep __ without reading __ ?

b. Kennedy (2000): 20a

I threw away more books than I kept __ without reading __.

As further evidence, Kennedy (2000, 2002) cites Grimshaw (1987)'s observation that contraction like that found in examples (183a-b) is ungrammatical in cases of comparative deletion.

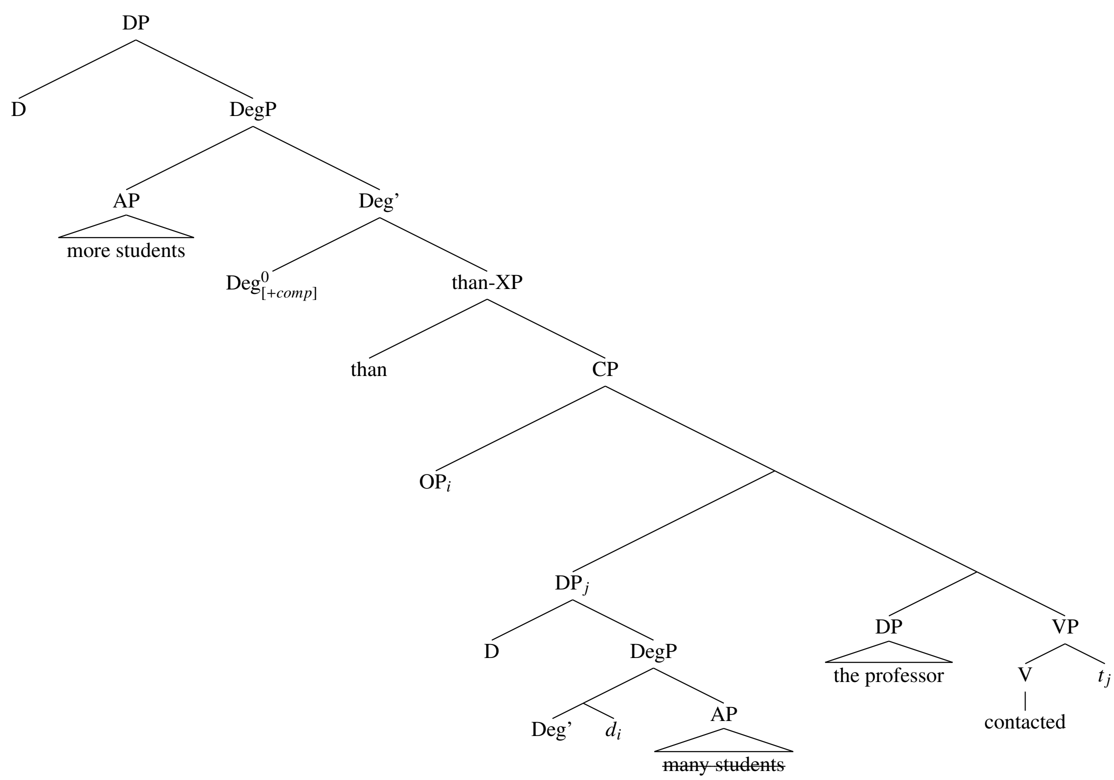
(183) Kennedy (2002):23a-b

a. I thought there was more meat than there is/*'s.

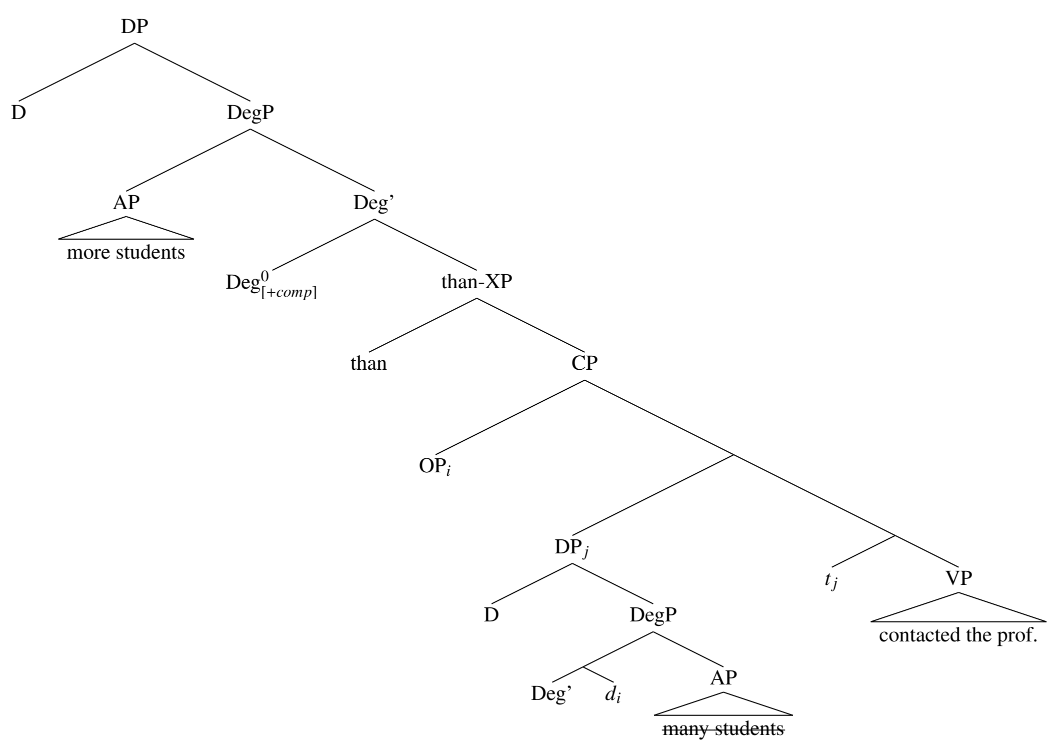
b. John was more upset then than he is/*'s now.

An analysis like that of Kennedy (2000) would not predict a subject island violation in cases like (177) because on his analysis, it is the entire subject that moves. A Kennedy-type analysis is shown for object gaps and subject gaps in (184) and (185), respectively. However, there may be a reason not to abandon an island account of subject gaps in comparative clauses too quickly. In order to obtain the correct semantic representation of the comparative clause, we would have to predict further movement of the degree operator on its own, without the entire DegP.

(184)



(185) No subject island violation:



If the entire DP moves out of subject position before movement of the degree operator, then no subject island violation would be predicted. However, den Dikken (2006) presents evidence against vacuuous movement of the highest subject in a sentence, which indicates that perhaps there is no movement of the entire subject DP in (177). If this is the case, then we would again expect sentences like (177) to involve movement out of a subject, and therefore incur a subject island violation. The argument that den Dikken makes predicts, for example, why there is no *do*-support in highest subject questions (186), and why most subject contact relatives are ungrammatical while other relative clauses can go without a relative pronoun or complementizer (187).

(186) den Dikken (2006):1a-c

a. who {ate/*did eat} the croquettes?

b. what did they eat?

c. why did they eat them?

(187) den Dikken (2006): 1a'-c'

a. the people *(who/that) ate the croquettes

b. the croquettes (which/that) they ate

c. the reason (why/that) they ate them

These facts, along with others that are beyond the scope of this discussion, lead den Dikken to define a stronger version of the Vacuous Movement Hypothesis (Chomsky, 1986) as in (188).

(188) Vacuous Movement Hypothesis (den Dikken, 2006)

Movement that does not cross phonologically or semantically visible material is prohibited.

Taking den Dikken's version of the Vacuous Movement Hypothesis, then the structures for (175) and (177) could be (184) and (178), respectively, with movement of the entire DP including DegP in the object case, but not in the subject case. This analysis - the movement for abstraction over degrees, plus the Vacuous Movement Hypothesis of den Dikken (2006) - would correctly predict the degraded status of subject gaps in comparative clauses.

There are, however, potential problems with attributing the subject gap penalty to an island violation. First, it may not explain the entire space of empirical data on subject extraction from comparative clauses. In Experiment 2, there was a (nonsignificant) trend toward a diminished subject gap penalty when the comparative clause was extraposed. If this difference turns out to be reliable in future experiments, then it would be a problem for an extraction-based account of the comparative clause/relative clause asymmetry because presumably, whatever syntactic or LF movement that occurs in the comparative clause in one linear order would also occur in the other.

Second, while subject island violations like that in (191) have been shown to resist syntactic satiation in a grammaticality judgment (although there was a trend toward satiation that was fairly close to significance) (Snyder, 2000). Structures that do not exhibit syntactic satiation are those that do not become acceptable after repeated exposure in an experiment. There appears to be intuitive variation in the acceptability of subject gaps in comparative clauses. For example, it seems like a passive comparative clause such as (189) or an inanimate associate of comparison (190) might be relatively acceptable (although this requires further empirical investigation).[4] If all subject gaps have the same island violation, this variation is not predicted.

(189) More people than __ were invited came to the party.

(190) More valuables than __ were taken from the castle were sold on the black market.

(191) Snyder (2000): 2d

*What does John know that a bottle of __ fell on the floor?

However, there are also suggestions in the literature that subject island violations do in fact lead to variable judgments of grammaticality/acceptability. Kluender (2004) presents an intuition that wh-extraction from tensed sentential subjects is less acceptable than wh-extraction from nonfinite subjects, as shown in (192a-192b). Kluender also claims that the grammatical configuration of the gap in a gerundive subject has an effect on acceptability. For instance, the question in (193b), with extraction from a PP is claimed to be more interpretable than (193c), with extraction of a direct object DP (I think I agree).

(192) Kluender (2004): 9-10

a. * Who does [that she can bake ginger cookies for __] give her great pleasure?

b. Who does [being able to bake ginger cookies for __] give her great pleasure?

[4] Both (189) and (190) have a reading which I call a *subset* interpretation, discussed further in Chapter 4. Under this intepretation, rather than simply comparing two number of people (the invited people and the party-attendees), a sentence like (189) would mean 'all of the people who were invited, plus some others, came to the party.' It is unclear as to whether or not such an interpretation could facilitate subject gaps.

(193) Kluender (2004): 12

a. Baking cookies for my grandchildren tires me out.

b. Who does baking cookies for __ tire you out?

c. What does baking __ for your grandchildren tire you out?

In the next section, I will present an argument for a subject island violation with variable acceptability in some Slavic phrasal comparatives from Pancheva (2010); Pancheva and Tomaszewicz (2010), and then discuss how this might apply to the clausal comparatives in question in this chapter.

4.2.1 Subject islands in Slavic phrasal comparatives

Pancheva (2010); Pancheva and Tomaszewicz (2010) observe a pattern of acceptability in phrasal comparatives in Slavic languages that has not previously been explained. Here I will present their data from Polish, although Pancheva (2010) shows that this holds for Bulgarian (and mentions that Greek and Hungarian show the same pattern). In Polish, unlike English, phrasal and clausal comparatives are distinguished morphologically by the standard markers *niż*, used for clausal comparatives (e.g., 194a), and *od*, used in phrasal comparatives (e.g., 194b).

(194) Pancheva (2010): 2

a. Jan waży więcej *niż* Agnieszka (waży).
   Jan weighs more than Agnieszka$_{NOM}$ (weighs).

b. Jan waży więcej *od* Agnieszki.
   Jan weighs more than Agnieszka$_{GEN}$.

   'Jan weighs more than Agnieszka (does).'

The curious asymmetry noted by Pancheva (2010) is that, when the *more*-NP (or in Polish the *więcej* -NP) is in subject position, phrasal comparatives like (195a) are degraded while the corresponding clausal comparative (195b) is acceptable. This leads Pancheva (2010) to propose the generalization in (196).

(195) Pancheva (2010):6

a. ??* *Więcej* *uczniów* zwiedziło Czechy *od* Słowacji.
   more students visited Czech.R. from Slovakia$_{GEN}$.

‘More students visited the Czech Republic than Slovakia.’

b. *Więcej* *uczniów* zwiedziło Czechy *niż* Słowację.
more students visited Czech.R. from Slovakia$_{ACC}$
‘More students visited the Czech Republic than Slovakia.’

(196) Generalization (Pancheva, 2010):

In the Slavic languages, a *more*-NP cannot be an underlying subject (an external argument) in phrasal comparatives.

Continuing to use Polish as an example (because it is the language that (Pancheva and Tomaszewicz, 2010) focus on), the examples in (197) show that the argument associated with the degree variable may be an a predicative adjective (as in 197a), a modifier (as in 197b) or an object (197c).

(197) Pancheva (2010): 7

a. Czechy są *większe od* Słowacji.
Czech.R are bigger from Slovakia$_{GEN}$
‘The Czech Republic is bigger than Slovakia.’

b. Marek zwiedził Czechy *wczéniej od* Słowacji.
Marek visited Czech.R. earlier from Slovakia$_{GEN}$
‘Marek visited the Czech Republic earlier than Slovakia.’

c. Marek zwiedził *wiécej miejsc od* Anny.
Marek visited more places from Anna$_{GEN}$.
‘Marek visited more places than Anna.’

Pancheva (2010) proposes that this asymmetry provides support for an analysis of phrasal comparatives in which the complement to *od* is a small clause (Pancheva, 2006). Under this analysis, while a phrasal comparative is not reduced from a full clause as would be assumed by a Reduction Analysis (e.g., Lechner, 2004), there is underlying structure in the *than*-phrase (or in this case, *od*-phrase) beyond the spoken material, and the *more-NP* in the main clause does have an unspoken counterpart in the *than*-phrase.[5] The remnant in the phrasal comparative moves to the left edge of the small clause, and then the rest of the small clause is elided.

The LFs for the *than*-phrases in examples (195a) and (197c) are shown below in (198a) and (b), respectively. The portion of the small clause that is elided is struck out. To put the generalization in (196) in terms of the underlying syntax of the *than*-phrase, the degraded cases are those wherein the Degree Phrase is a part of the underlying small clause subject, as in (198a).[6]

(198) Pancheva (2010): 18

a. *od* [$_{PredP}$ Slovakia$_3$ ~~[$_{vP}$ [d$_2$-many students visit x$_3$]]~~

b. *od* [$_{PredP}$ Ana$_3$ ~~[$_{vP}$ x$_3$ visit d$_2$-many places]]~~

The way that Pancheva (2010) derives the difference in acceptability between (198a) and (b) depends on the assumption of movement of the degree term out to the left edge of the small clause. There are two possibilities for this movement: first, that the entire DP, including the degree, moves, and the second is that only the degree moves and not the rest of the NP. According to Pancheva, the first option leads to ungrammaticality due to an anti-locality violation, as formulated in (199). Moving a subject of a small clause to its interpretation position involves movement from Spec, *v*P to Spec, *v*P. This problem does not arise in clausal comparatives because they contain more structure to which the subject can move. The violations of the anti-locality constraint is shown for (200a). Movement from object position to Spec, *v*P does not incur a violation, as shown in (200b).

(199) *Anti-Locality Constraint on Specifiers*:

The Specifier of a head H cannot more to a Specifier of H.

---

[5]Pancheva derives the Case facts that form a major argument against a clausal analysis of phrasal comparatives, as in (i), by assigning the remnant accusative case by ECM.

i. I bought more candy than her.

[6]Pancheva and Tomaszewicz (2010) disclude from their experiment and discussion examples wherein the degree phrase is a part of the remnant in the phrasal comparative, as in (i). Further confirmation is needed to tell whether these examples are acceptable in Polish.

i. Pancheva and Tomaszewicz (2010): 13b
More students read books than [wh-many$_1$ [d$_1$ professors$_2$ [$_{vP}$ t$_2$ read books]]

(200) Pancheva (2010): 25c,a

a. *od* [$_{PredP}$ Slovakia$_3$ ~~[$_{vP}$ [*wh*-many students$_2$ [$_{vP}$ x$_2$ visit x$_3$]]~~

b. *od* [$_{PredP}$ Ana$_3$ ~~[$_{vP}$ *wh*-many places$_2$ [$_{vP}$ x$_3$ visit x$_2$]]~~

The second option is that it is not the entire DP including the degree that moves, but rather simply the degree itself. While this does not incur a violation of the antilocality constraint (200), it does involve extraction out of a subject, meaning that it incurs a subject island violation. Pancheva (2010) and Pancheva and Tomaszewicz (2010) claim that this subject island violation is the source of gradient unacceptability in Polish phrasal comparatives, rather than categorical badness.

(201) Pancheva (2010): 31

??/* *od* [$_{PredP}$ Slovakia$_3$ ~~[$_{vP}$ [*wh*$_2$ [$_{vP}$ d$_2$-*many students* visit x$_3$]]~~

Given that the facts on phrasal comparatives in Polish indicate a gradient, variable degradation for examples like (195a), Pancheva and Tomaszewicz (2010) adopt the latter analysis with movement of the degree only.

If movement of the degree only, resulting in a subject island violation, is general for comparatives and not just phrasal ones, then the acceptability of (195b) must be explained. The logical form of a clausal comparative like (195b) is shown in (202). Why should extraction from a subject be banned in phrasal but not in clausal comparatives?

(202) *niż* [$_{CP}$ *wh*-many students$_2$ [$_{TP}$ Slovakia$_1$ [$_{TP}$ T$_{PAST}$ [$_{vP}$ x$_2$ visited *x*$_1$]]]]

Presumably, the clausal equivalent to the ungrammatical phrasal comparatives, for example (195b), is allowed not because the islandhood of subjects varies between phrasal and clausal comparatives, but because the locality condition does not preclude extraction of the entire DP from subject position in clausal comparatives. If Polish phrasal comparatives follow the strategy of extracting the entire subject, then the grammaticality difference between Polish phrasal and clausal comparatives is predicted.

A complicating factor, however, is that in the case of clausal comparatives there is reason to believe that the amount of deletion could play a role in the acceptability of the sentence. Barbara Tomaszewicz (p.c.), gave an intuition that clausal comparatives are degraded if there is unelided redundant material, such as the verb *visited* in (203a). Tomaszewicz notes that the reason for this degradation may be due to the interpretation of the subject gap as a null pronominal subject. However, she claims that the sentence improves if different verbs are used between the matrix VP and comparative clause, as in (203b). Example (203c) is a more felicitous version of this structure.

(203) a. Więcej studentów odwiedziło Czechy niż odwiedziło Słowację.
more students visited Czech.R. *niż* visited Slovakia
'More students visited the Czech Republic than visited Slovakia.'

b. Więcej studentów odwiedziło Czechy niż studiowało w Słowację.
more students visited Czech.R. *niż* studied in Slovakia
'More students visited the Czech Republic than studied in Slovakia.'

c. Więcej studentów kupuje nowe komputery, *niż* sprzedaje stare.
More students buy new computers *niż* sell old
'More students buy new computers than sell old (ones/computers)'

While there is some variation in the intuitive acceptability of subject gaps in sentences like (203a-203c), an example with a subject gap when the comparative clause is in base position is, according to Tomaszewicz, unacceptable. She states that the only way to express a sentence with the *niż* -phrase in this position is with an example like (205), which uses a relative clause. However, it is not the case that there are no examples where *niż* follows the more-NP directly, as shown in (206).

(204) *Więcej studentów niż studiowało w Słowację odwiedziło Czechy.
more students *niż* studied in Slovakia visited Czech.R.
'More students than studied in Slovakia visited the Czech Republic.'

(205) #Więcej studentów *niż* tych, którzy studiowali w Słowacji, pojedzie do Czech.
#More students than those who studied in Slovakia will.go to Czech Rep.

(206) Więcej ludzi *niż* chciałam przyszło na imprezę.
More people than I.wanted came to party
'More people than I wanted came to the party.'

The facts show that in Polish too, subject gaps in comparative clauses are unacceptable in base position. In extraposed position, subject gaps are possible, but show variability based on the amount of redundant material in the comparative clause.

4.2.2 Is a subject island account viable?

Attributing the processing penalty and drop in naturalness ratings for subject gaps in comparative clauses to a subject island violation would align the accounts of English clausal comparatives and Slavic phrasal comparatives. However, such an account would also have to argue against the evidence presented by Kennedy (2000, 2002), that comparative deletion involves movement of the entire compared constituent, which in the subject gaps case would be the entire subject. Such an account would also have to explain the unpredicted amelioration of subject gaps in comparative clauses in extraposed position. The next sections will explore alternate accounts that may fare better in accounting for the empirical data.

One further prediction of this analysis is that embedded subject gaps in comparative clauses should be more acceptable than highest subject gaps, because the movement operation required to get the compared constituent to the left periphery of the comparative clause would not be vacuous. While further empirical study is required for confirmation, intuitively it seems that this might be the case. Compare for example (207), which has a gap in an embedded subject position, and (208), which has a gap in highest subject position. By my intuition (207) is the more natural example.

(207) More students than I believe went to office hours were likely to fail the class.

(208) More students than went to office hours were likely to fail the class.

There seems to be good reason to think that the subject gap penalty is due to an underlying subject island violation, as such an account predicts many of the effects observed in Experiments 1 and 2. This account, as developed here, is summarized in (209).

(209) *Subject gap penalty: Island Account*

a. In comparative clauses, the Vacuous Movement Hypothesis (den Dikken, 2006) prevents movement of the entire subject DP to the periphery of the comparative clause (whereas other arguments containing DegPs do move).

b. The degree operator must move out of the subject DP in order to form lambda abstraction over the comparative clause, resulting in a subject island.

c. The subject gap penalty shows variation because there is variation in the acceptability of subject islands in general.

Nevertheless, it is important to consider other possible accounts that may straightforwardly predict distinctions in the data, for example the difference between subject-gap comparative clauses between base and extraposed position, that the Island Account must chalk up to ill-defined variability in the acceptability subject island violations.

4.2.3 Order of information in comparatives

One semantic reason for the difficulty with subject gaps in comparatives could be the order with which the reader/hearer gets the information needed to form a comparative representation. In subject-extracted comparative clauses, no information about the standard of comparison is encountered before the reader/hearer must discover the location of the degree.

(210)	More	friends	than	**we talked to**	___ were at	the party
	more	assoc.	than	**standard**	GAP	

(211)	More	friends	than	___	**talked to us**	were at the party
	more	assoc.	than	GAP	**standard**	

When a comparative clause is extraposed, more information (in the form of the main VP) is available before the gap, which might help the comprehender.

(212) *Comparative Order Hypothesis*:

The more information available before the degree/gap site in a comparative clause, the easier processing will be.

The Comparative Order Hypothesis can also account for the smaller penalty for subject gaps in extraposed comparative clauses in Experiment 1, because the extra information from the main VP preceding the comparative clause may facilitate processing of the gap site.

The Japanese study in Section (4.3) will be informative for an information flow-based theory because the structure of comparatives and relative clauses in Japanese (and other languages with pre-nominal relative clauses) makes the information flow crucially different from English. Japanese, the entire standard of comparison always precedes the associate of comparison.

(213) a. keikan-ga oshita yori ookuno hannin-ga saibansho-de bengoshi-o
policeman-NOM shoved YORI many criminal-NOM courthouse-at lawyer-ACC
ketta
kicked
'More criminals than the policeman shoved kicked the lawyer at the courthouse'

b. keikan-o oshita yori ookuno hannin-ga saibansho-de bengoshi-o
policeman-ACC shoved YORI many criminal-NOM courthouse-at lawyer-ACC
ketta
kicked
'More criminals than shoved the policeman kicked the lawyer at the courthouse'

4.3 Subject and Object Gaps in Japanese

In Chapter 3, I introduced the hypothesis that the subject gap penalty in comparative clauses arises from a processing bottleneck, in this case a revision of structure and gap-filling operation that must be performed at the same point in the sentence. This hypothesis did not receive unequivocal support from the self-paced reading data in Experiment 5. In this chapter, I have presented an alternative analysis based on subject island violations. In this section, I will present a pilot study performed in Japanese that could provide further disconfirmation of a processing bottleneck account, and preliminary support toward a subject island or order of information account. I will investigate comparative and relative clauses in Japanese, a language with head-final word order and pre-nominal relative clauses. I will first introduce some properties of comparatives and relative clauses in Japanese and other languages with similar word order, and then describe our study.[7]

[7]The Japanese study was developed in collaboration with Christopher Davis at Kyoto University and University of the Ryukus, with crucial input also from Shoichi Takahashi at Nihon University in Tokyo. All errors and omissions remain my own.

4.3.1 Comparatives and Relative Clauses in Japanese

4.3.1.1 Relative Clauses

Japanese is a head-final language that has pre-nominal relative clauses. Relative clauses like (214), from Kuno (1973), and (215), from Shimoyama (1999), have no overt relative pronoun. These examples are called 'head-external' relative clauses (Shimoyama, 1999) because the head noun, in this case *tegami* or *keeki* appears outside of the relative clause.

(214) Kuno (1973): 57

Mary-ga kaku tegami-wa omosiroi.
Mary-NOM write letter-TOP interesting-is

'Letters that Mary writes are interesting.'

(215) Shimoyama (1999):1

Yoko-wa [[Taro-ga sara-no ue-ni *e* oita] keeki]]-o tabeta
Yoko-TOP Taro-NOM plate-GEN on-LOC *e* put cake-ACC ate

'Yoko ate a piece of cake which Taro put on a plate.'

While this chapter is concerned with the head-external type of relative clause, it is worth noting that Japanese also has what are called head-internal relative clauses. Example 216, also from Shimoyama (1999), includes *keeki-o* inside the relative clause (preceding the relative clause verb due to the SOV order of Japanese). This type of example also has a nominalizer *-no* on the relative clause.

(216) Shimoyama (1999):2

Yoko-wa [Taro-ga sara-no ue-ni keeki-o oita]-no]-o tabeta.
Yoko-TOP Taro-NOM plate-GEN on-LOC cake-ACC put-NM-ACC ate
'Yoko ate a piece of cake which Taro put on a plate.'

4.3.1.2 Comparatives

Japanese comparatives have several properties that distinguish them from English-type comparatives. Japanese lacks a comparative morpheme like English *-er* (although see Sawada, to appear for evidence that this is changing), a property that is cross-linguistically common (see Stassen, 1985). The standard of comparison is marked by *yori*, which functions elsewhere as a preposition often translated as 'from'. In Japanese, the standard of comparison marked by *yori* precedes the associate of comparison. Example (217) shows a subject-gap comparative clause and an object-gap comparative clause. In both of these examples, the comparative clause occurs before the associate of comparison (*uma-ga*, 'horses'). The word *ooku-no* or 'many' provides the scale on which the comparison is being made, in this case cardinality.

(217) a. yagiu-o ketta yori ookuno uma-ga kodomo-nimukete ureshiku naita
goats-ACC kicked YORI many horses-NOM children-at happily whinnied
'More horses than kicked the goats whinnied happily at the children.'

b. yagiu-ga ketta yori ookuno uma-ga kodomo-nimukete ureshiku naita
goats-NOM kicked YORI many horses-NOM children-at happily whinnied
'More horses than the goats kicked whinnied happily at the children.'

Investigating the processing of subject and object gaps in Japanese comparatives is an ideal complement to the investigation developed so far in English. Having the standard of comparison come before the associate (and the property of comparison) eliminates the possibility that unfulfilled expectations regarding the complement to the standard marker (for instance, the expectation of an NP rather than a clause) are behind any processing differences between subject and object gaps, because in each case the entire comparative clause has been processed before the standard marker *yori*.

4.3.2 Previous results on the processing of relative clauses in Japanese and other languages with pre-nominal RCs

The processing profile of relative clauses in languages where these occur pre-nominally has an important role in evaluating theories based on data from the processing of relative clauses in English and other languages with post-nominal relative clauses. While many aspects of relative clauses differ based on the position of the relative clause, such as the linear distance between the gap site and the head noun in subject versus object relatives, others, such as the relative frequency of subject vs. object relatives or the number of perpective shifts (as per MacWhinney, 1982). As a result, there have been several studies on the processing of relative clauses in languages with pre-nominal relatives, for example Japanese, Korean, and Mandarin Chinese. The results of these studies vary (especially those from Mandarin), with some variation potentially due to temporary ambiguities in sentences with pre-nominal relatives. Below, I will discuss some of the results from experiments testing subject and object gaps in relative clauses in Japanese, as well as Korean and Mandarin.

An early study on the processing of relative clauses in Japanese was performed by Yamashita et al. (1993). Rather than focusing on the gap type in relative clauses, they investigated different types of relative clauses: *Regular* relative clauses, as in (218a), and *Gapless* relative clauses, like (218b). Yamashita et al. conducted a self-paced reading study using these two types of relative clauses to test first whether postulating an empty category (as is required in Regular but not Gapless relative clauses) incurs a processing cost, and second whether a missing argument helps to signal to readers that the presence relative clause rather than a simple main clause.

(218) Yamashita et al. (1993): 19 (formatting modified)

a. Yokohama-de [$_{RC}$kodomo-ga nessinni mati-de e_i utta] sisyuu$_i$-ga hookago
Yokohama-at children-NOM ardently town-at *e* sold anthology-NOM after-school
kaisyuu-sareta.
was-collected
'In Yokohama, the anthologies (which) the children sold in town was (were) collected after school.'

b. Yokohama-de [$_{RC}$kodomo-ga nessinni sisyuu-o utta] okane-ga hookago
Yokohama-at children-NOM ardently anthology-ACC sold money-NOM after-school
kaisyuu-sareta.
was-collected.
' In Yokohama, the money from the children's selling of anthologies was (were) collected after school.'

Yamashita et al. found a 61ms penalty for Regular relative clauses at the head noun (*anthology/money*). This effect reversed on the subsequent region (*after-school*), with a 52ms penalty for Gapless relatives (although the difference was only marginally significant by items). The authors interpret both of these effects as spillover from the previous region. The effect on the head noun is attributed to difficulty postulating an empty category at the Regular RC verb, even though the authors note that empty categories are very common in Japanese. The effect on the subsequent region is attributed to an unexpected disambiguation toward a Gapless relative clause interpretation in the absence of an early signal. The authors conclude that verb subcategorization information is exploited immediately in processing, causing readers to adjust their expectations depending on whether or not all arguments have been realized.

In the literature on processing subject and object relative clauses in Japanese, several studies (including Miyamoto and Nakamura, 2003; Sheldon, 1976; Ishizuka, 2005; Ueno and Garnsey, 2008) have found an advantage for subject relatives over object relatives. Miyamoto and Nakamura (2003) investigated subject and object relative clauses in Japanese in two self-paced reading studies. In their first self-paced reading experiment, they found that reading times on the head noun (*girl* in (219)) were longer for object relatives than for subject relatives. A second experiment showed that this effect held for head nouns that were topic-marked (with *-wa*) or subject marked (*-ga*), but was not significant for with those that were marked as objects (with *-o*). On subsequent regions, there was a general advantage for subject gaps.

(219) Miyamoto and Nakamura (2003)

a. Subject relative:

Tosiyorino obaasan-ga basutei-made miokutta onnanoko-wa nuigurumi-o
elderly woman-Nom busstop-to accompanied girl-Top stuffed-toy-Acc
daiteita.
hugging
'The girl that the elderly woman accompanied to the bus stop was holding a stuffed toy.'

b. Object relative:

Tosiyorino obaasan-o basutei-made miokutta onnanoko-wa nuigurumi-o
elderly woman-Acc busstop-to accompanied girl-Top stuffed-toy-Acc
daiteita.
hugging
'The girl that accompanied the elderly woman to the bus stop was holding a stuffed toy.'

Miyamoto and Nakamura take the latter result as an argument against the role of parallelism in processing subject and object relatives. If parallelism were the crucial factor in determining processing time, then one would expect to find an advantage for object gaps with an object head noun, and this no such advantage was found.

In another study of the processing of subject and object gaps in Japanese relative clauses, (Ishizuka, 2005, also presented as Ishizuka et al., 2003) also found an advantage for subject-gaps in a self-paced reading study. Ishizuka tested subject and object-gaps in relative clauses at single and double levels of embedding (see an example item set in 220a-d), and found that object relatives were read slower than subject relatives at the head noun for singly-embedded relatives (although the analysis by subjects was not significant). For embedded relative clauses, the advantage for subject gaps was found on the a post-head region. In order to control for possible processing difficulty due to case mismatch between the head of a relative clause and the case that its corresponding gap in the relative clause would bear, conditions (220e-f) were included in the study. Here, the head noun was nominative for the subject gap condition and accusative for the object gap condition. Ishizuka found that in the case matching conditions, there was a numerical (but nonsignificant) trend toward an advantage for subject-gap relatives at the head noun. Overall the case matching conditions were read faster at the head noun than the corresponding case-clashing conditions (220c-d).

(220) Sample materials, Ishizuka (2005):

a. Singly embedded, object-gap:

[kuruma-ga e_i	tuisekisita]	ootobai-ni-wa$_i$	kookosei-ga	notteita.
car-NOM e	chased	motorbike-DAT-TOP	high-school-student-NOM	rode.

' A high school student was on the motorbike which the car chased.'

b. Singly-embedded, subject-gap:

[e_i kuruma-o	tuisekisita]	ootobai-ni-wa$_i$	kookoosei-ga	notteita.
e car-ACC	chased	motorobike-DAT-TOP	high-school-student-NOM	rode.

'A high school student was on the motorbide which chased the car.'

c. Doubly embedded, object-gap:

[[torakku-ga e_i oikosita] kuruma-ga$_i$ e_j tuisekisita] ootobai-ni-wa$_j$

truck-NOM *e* passed car-NOM *e* chased motorbike-DAT-TOP

kookoosei-ga notteita.

high-school-student rode.

'A high school student was on the motorbike which the car which the truck passed chased.'

d. Doubly embedded, subject-gap:

[e_j [e_i torakku-o oikosita] kuruma-o$_i$ tuisekisita] ootobai-ni-wa

e *e* truck-ACC passed car-NOM chased motorobike-DAT-TOP

kookoosei-ga notteita.

high-school-student-NOM rode.

'A high school student was on the motorbike which chased the car which passed the truck.'

e. Subject-gap, case matching of head noun to the empty category in the embedded RC:

[e_i torakku-o oikosita] kuruma-ga$_i$ tuisekisita ootobai-ni-wa

e truck-ACC passed car-NOM chased motorbike-DAT-TOP

kookoosei-ga notteita.

high-school-student-NOM rode.

'A high school student was on the motorbike which the car which passed the truck chased.'

f. Object gap, case matching of head noun to the empty category in the embedded RC:

[torakku-ga e_i oikosita] kuruma-o$_i$ tuisekisita ootobai-ni-wa

truck-NOM *e* passed car-ACC chased motorbike-DAT-TOP

kookoosei-ga notteita.

high-school-student-NOM rode.

'A high school student was on the motorbike which chased the car which the truck passed.'

The advantage for subject gaps in Japanese relative clauses does not support a DLT account of relative clause processing, but is rather more congruent with a Structural Depth Hypothesis account

(O'Grady et al., 2000). However, Ishizuka et al. (2003); Ishizuka (2005) suggests that the results of this experiment might be confounded by a garden-path effect found in the object relative items, but not in the subject relative clauses. When readers encounter a nominative noun as the first word in the sentence, as in (220a), they are not immediately aware of the presence of a relative and are likely to think that they are reading a matrix clause. However, when readers encounter an accusative-marked noun as the first word in the sentence, they are immediately aware of a non-canonical word order. In order to eliminate this confound, Ishizuka et al. (2006) conducted a study using linguistic contexts that would set the reader up to believe that they are reading a relative clause in the target sentence.

(221) Ishizuka et al. (2006): Materials (English translation)

Context:

A reporter interviewed a writer on a TV program. Then the writer interviewed another reporter for his new novel.

Taro: "Which reporter stands as a candidate for the election?"

a. Object gap: It seems to be the reporter who the writer interviewed.

b. Subject gap: It seems to be the reporter who interviewed the writer.

In this study, Ishizuka et al. (2006) found an advantage for object gaps over subject gaps, leading the authors to suggest that the previous results were due to the temporary ambiguity in object-gap relatives in Japanese. However, the object-gap advantage in context has come into question because the effect proved not to be replicable (see footnote 11 in Kwon et al. (2010)).

Ueno and Garnsey (2008), like Miyamoto and Nakamura (2003), found a penalty (of 47ms) in reading times at the head noun for object relatives as compared to subject relatives. At the relative clause verb, however, there was a numerical advantage for object relative clauses (significant by items but not by subjects). A subsequent ERP study showed an increase in bilateral anterior negativity at the relative clause verb for object relatives, which signals syntactic processing difficulty in object relatives. The authors propose that the negativity reflects the relative difficulty of positing a subject gap, which is at the 'top' of the clause, and positing an object gap, which is farther in 'structural distance' (being lower in the syntactic tree) from the clause level. At the head noun, Ueno and Garnsey found that object relative clauses had an increased centro-posterior positivity compared to subject relatives. While the effect was not a clear P600 effect due to a somewhat different timecourse, and the authors take this effect to be the result of increased integration difficulty in ORCs, consistent with their reading time results. Ueno and Garnsey (2008) interpret these results as supporting a structural-distance account of processing difficulty in relative clauses, as this account predicts that object relatives should be more difficult than subject relatives for both post-nominal relative clauses, as in English, and pre-nominal relatives, as in Japanese.

The results of the studies discussed point to an advantage for subject gaps over object gaps in Japanese relative clauses. This advantage has also been found for Korean (Kwon et al., 2006, 2010), which has a similar structure to Japanese. However, the results for Mandarin, which also has pre-nominal relative clauses (although has canonical SVO structure, as opposed to SOV for Japanese and Korean), are more mixed. Some studies have found a subject gap advantage (Lin and Bever, 2006; Chen et al., submitted) while others have found (Hsaio and Gibson, 2003; Gibson and Wu, in press; Chen et al., 2008) have found an advantage for object gaps. These results also vary in the position at which the effect is found, which may be important in interpreting the results (see Qiao et al., 2011), and may reflect difficulty due to syntactic ambiguities as well as difficulty in resolving the gap-head dependency.

4.3.3 Experiment 6

In order to obtain data that will help to decide between the classes of hypotheses proposed in the previous sections, a self-paced reading study of comparative clauses in Japanese was developed. This study, like Experiment 3, included subject and object gaps in comparative clauses as well as subject and object relative clauses. In order to keep the relative clause and comparative conditions as near identical as possible, the relative clauses had the quantifier *ookuno* (‘many’) as the determiner on the relative clause head.

4.3.3.1 Method

4.3.3.1.1 ***Materials*** Twenty-eight sets of sentences like the one in (222) were constructed. In all conditions, the sentence started with an embedded clause (either a relative clause or comparative clause) with either a subject or object gap. The comparative sentences then continued with the standard marker *yori-mo*. In Japanese *mo* is optional after *yori*, but it avoids an undesired ambiguity in the materials. Pilot experimental subjects noted that the sequence *yori ooku-no* can have a meaning like ‘rather many’ instead of a true comparative reading. The particle *mo* was therefore included for the experimental subjects in order to avoid the ‘rather many’ reading. All conditions contiued on with *ooku-no* (‘many’), then the associate of comparison/relative clause head noun. The subsequent region was recorded as a spillover region. The sentences varied in length, ranging from zero to five regions after the recorded spillover region. The sentences were presented in Japanese kanji, hiragana and katakana as appropriate. All materials used in the experiment can be found in Appendix A.

(222) Sample Materials, Experiment 6 (/ delimits presentation regions).

a. yagiu-ga/ ketta yori-mo/ ooku-no/ uma-ga/ kodomo-nimukete/ ureshiku/
goats-NOM kicked YORI-MO many horses-NOM children-at happily
naita
whinnied
‘More horses than the goats kicked whinnied happily at the children.’

b. yagiu-o/ ketta yori-mo/ ooku-no/ uma-ga/ kodomo-nimukete/ ureshiku/
goats-ACC kicked YORI-MO many horses-NOM children-at happily
naita
whinnied
‘More horses than kicked the goats whinnied happily at the children.’

c. yagiu-ga/ ketta/ ooku-no/ uma-ga/ kodomo-nimukete/ ureshiku/ naita
goats-NOM kicked many horses-NOM children-at happily whinnied
‘Many horses that the goat kicked whinnied happily at the children.’

d. yagiu-o/ ketta/ ooku-no/ uma-ga/ kodomo-nimukete/ ureshiku/ naita
goats-ACC kicked many horses-NOM children-at happily whinnied
‘Many horses that kicked the goat whinnied happily at the children.’

Ueno and Garnsey (2008), like Ishizuka (2005), controlled for the match or mismatch in between the case head noun and the case that the gap site would have, were it realized, by choosing predicates that take dative topic-marked subjects. It has been suggested that having a mismatch in case may have an effect on processing (Sauerland and Gibson, 1998). For our materials, it would have been too complex to form examples that were felicitous in both comparative and relative clause materials as well as using dative topics. In order to determine whether any experimental effects we find could be due to case match or mismatch, we included twelve items from Ueno and Garnsey (2008) in our experiment as controls. An example item set is in (223).

(223) a. Subject relative:

sinnin-no	giin-o	hinan-sita	kisha-ni-wa	naganen-no
new.person-GEN	parliamentarian-ACC	criticized	reporter-DAT-TOP	long.years-GEN

aibou-ga	ita
partner-NOM	existed

'The reporter who criticized the new parliamentarian had a long-time partner.'

b. Object relative:

sinnin-no	giin-ga	hinan-sita	kisha-ni-wa
new.person-GEN	parliamentarian-NOM	criticized	reporter-DAT-TOP

naganen-no	aibou-ga	ita
long.years-GEN	partner-NOM	existed

'The reporter who the new parliamentarian criticized had a long-time partner.'

4.3.3.1.2 Procedure Twenty native speakers of Japanese participated in the experiment at the University of Kyoto. Subjects were tested individually on a PC computer using Linger software (Rohde, 2003). After reading written instructions, subjects read a practice block of five sentences to get accustomed to the self-paced reading paradigm. After the practice, each subject read the 28 experimental items along with 78 filler questions. After approximately one third of the trials (32%), subjects were asked to answer a comprehension question about the sentence they just read, using a button press.

4.3.3.2 Results

Data from the question accuracy showed that over all of the 34 comprehension questions in the experiment (including those for the fillers), subjects had a mean accuracy of 79.8%. One subject showed less than 70% accuracy on the comprehension questions and was therefore removed from the reading time analyses.

Visual inspection of the data revealed six extreme values, which were above 8000ms for a single region. These were removed, and then the data were trimmed to 3 standard deviations of the subject by region mean. In total the outlier removal process removed 90 observations, or 2.2% of observations in the entire data set.

Mean reading times for all regions are shown in Figure (4.2). There are six regions of interest in the reading time analyses: the embedded noun, embedded verb, *yori-mo* (for the comparative conditions), *ooku-no*, the head noun or associate of comparison, and the immediate spillover region. There were no significant differences on the embedded noun or embedded verb regions. On *yori-mo*, there was a numerical advantage for the comparative, object gap condition, but the effect did not reach significance (Estimate = 77.1, SE = 47.98, t = 1.61). There were no significant differences on the *ooku-no* region. On the associate of comparison, there was a numerical interaction such that the comparative, subject gap condition had the longest reading times of any condition, but again the interaction did not reach significance (Estimate = -297.52, SE = 188.47, t = -1.58). The spillover region showed a significant effect of sentence type, with comparatives having longer reading times than relative clauses (Estimate = -161.71, SE = 53.67, t = -3.01), but no other effects reached significance. Model parameters for the main regions of interest, *yori-mo* through the spillover region, are included in Appendix C.

The control items from Ueno and Garnsey (2008) showed a penalty for the object relative clause condition over the subject relative clause condition. This difference was numerically present over the entire sentence, but reached significance only on the head noun region (Estimate = -251.26, SE = 120.15, t = -2.09).

4.3.3.3 Discussion

The pilot data from Japanese provide some suggestive, although certainly not definitive, evidence for the debate about the nature of the subject gap penalty in comparative clauses. If the subject gap penalty for comparative clauses in Japanese turns out to be a replicable effect, then the processing bottleneck hypothesis cannot be sufficient to explain the processing of comparative clauses cross-linguistically. Japanese word order necessitates that all of the material in a comparative clause is encountered prior to the standard marker *yori(mo)*, and therefore a subject gap penalty

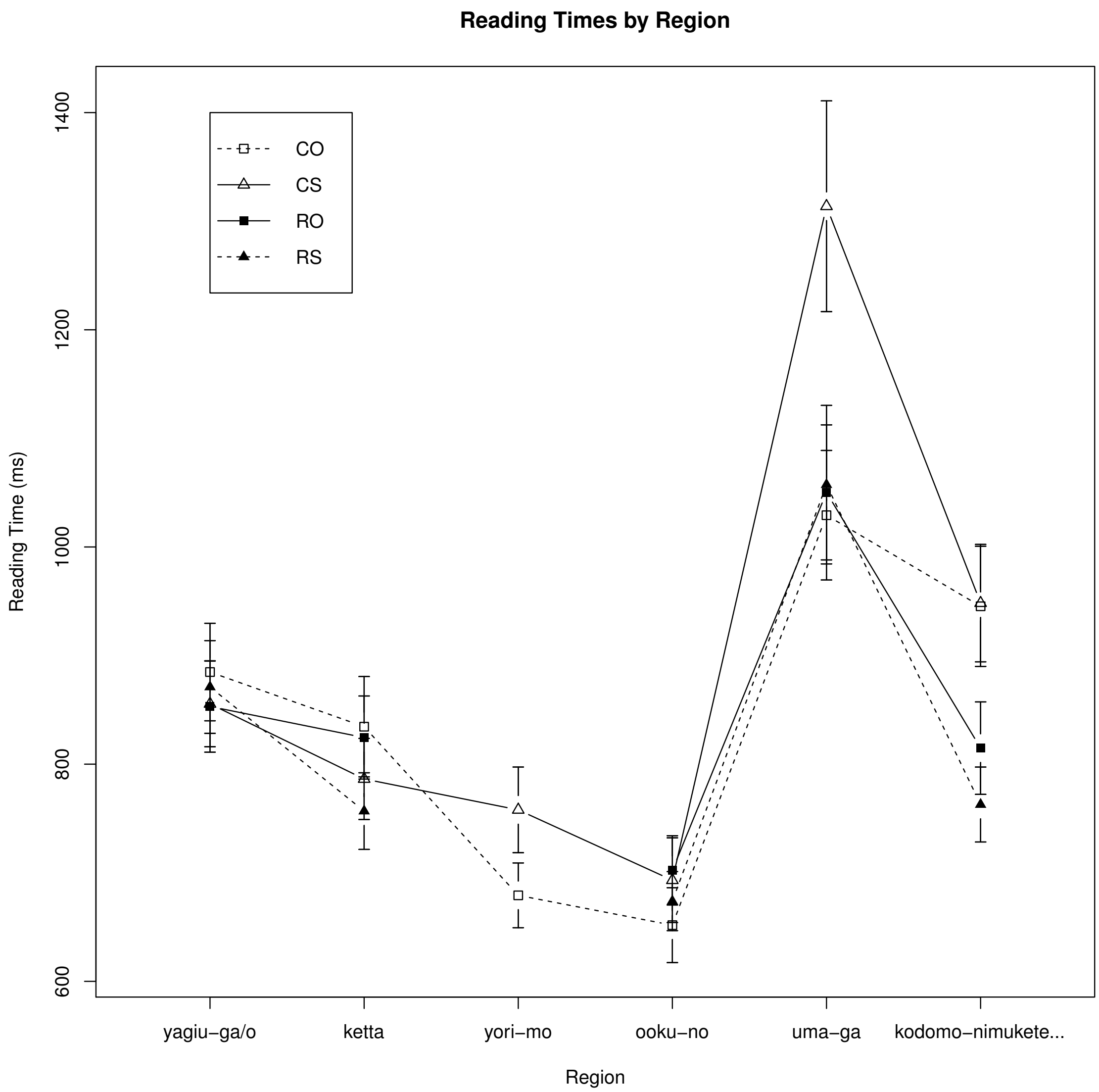


Figure 4.1. Mean reading times by region, Experiment 6.

Note: The regions shown are the embedded clause subject or object, embedded verb, *yori-mo* (for the comparative conditions), *ooku-no*, the head noun or associate of comparison, and spillover region.

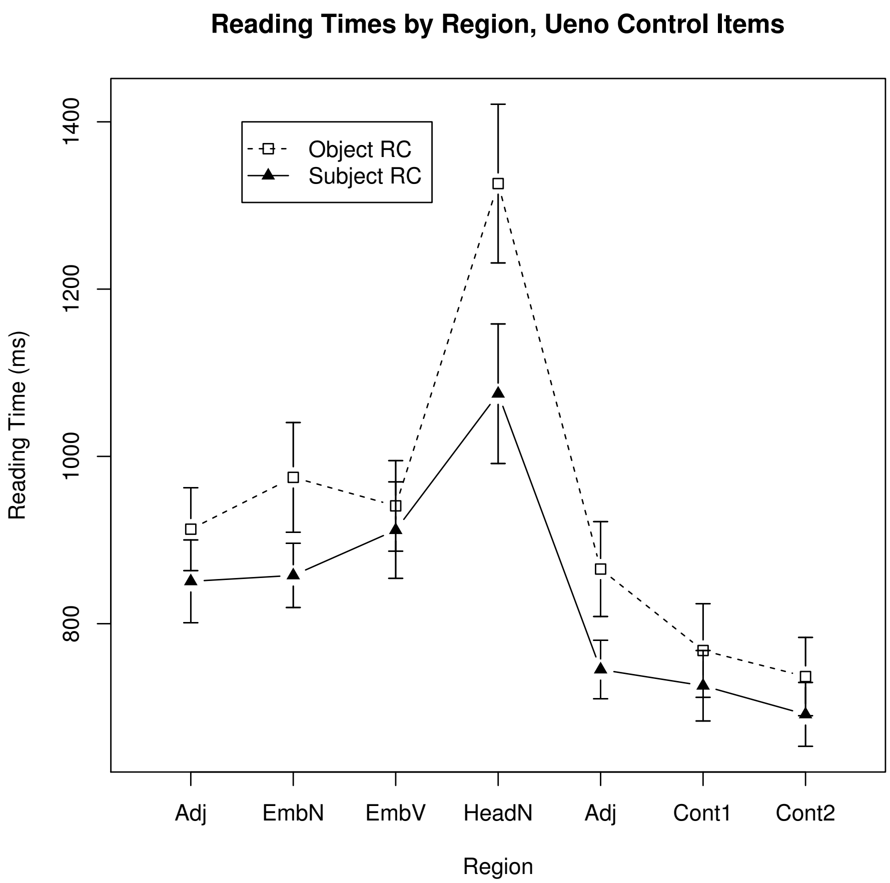


Figure 4.2. Mean reading times by region, Experiment 6 control items.

cannot be explained by an unfulfilled expectation about the complement of *yori(mo)* concurrent with a gap-filling operation.

The best account, therefore, appears to be the subject island violation account. However, several researchers (e.g., Lasnik and Saito, 1992; Kikuchi, 1987) have claimed that there Japanese subjects are not islands for extraction. Pancheva (2010) adopts this claim, and therefore does not predict that the restriction on Slavic phrasal comparatives should extend to wh-in-situ languages like Japanese. To illustrate the acceptability of sub-extraction from subjects in Japanese, the example that Kikuchi (1987) gives is, in fact, a subject gap in a comparative clause. Example (224) shows both an object gap (224a) and a subject gap (224b).

(224) Kikuchi (1987):2a, 3a

a. sokoni aru hon-ni tuite ie ba, [John-ga *e* yonda yorimo] Tom-wa takusan
there exist book-to about say if John-NOM *e* read YORIMO Tom-TOP many
yonde ita
read ASP
'As for the books over there, Tom read more books than John read.'

b. sanka-ninzuu-ni tuite ie ba [*e* ano kaizyo-ni ita yorimo] ookuno
the-number-of-students about say if *e* that place-at exist YORIMO many
gakusya-ga koko-ni iru.
scholars here-at exist.
'As for the number of the attendants, more scholars are here than were at the place.'

If subjects are not islands for extraction in Japanese, then the subject island account would also be insufficient to explain the suggestive data from Japanese. Recently, however, Jurka et al. (2011) argued that subjects are islands for extraction in Japanese, and possibly universally. While the experimental evidence that Jurka et al. (2011) provide does not show a penalty for extraction out of subjects, they do show that sub-extraction out of a subject in Japanese eliminates an acceptability rating advantage found for their non-extraction baseline condition.

It is possible that subject island violations in Japanese are not strong enough to cause ungrammaticality, but that they do cause difficulty in processing. This is not implausible, given the variability of subject island violations in English and in Polish. There is also independent evidence that a constraint that is grammaticalized in one language may emerge as a processing preference in another (see e.g., Häussler et al. (under review), for such an argument regarding superiority effects). Further evidence on the acceptability and processing difficulty of subject island violations in Japanese is required to support or disconfirm such an analysis.

The reading time data from Experiment 6 also showed an advantage for relative clauses over comparatives in the spillover region (following the relative clause head or associate of comparison). While this difference is consistent with an overall penalty for comparatives as compared to relative clauses found in English in Experiment 3 of Chapter 3, the effect in English appeared to be driven by the interaction between gap type and clause type, while on the spillover region in Experiment 6 there is no apparent interaction. It is not straightforward to interpret the difference on this region, because the effect could be due to a difference in linear position of the spillover region in relative clauses versus comparative clauses, in which this region is one position later in the sentence. However, it is also possible that the difference is due to something other than linear position. The effect could be a delayed effect of the comparative clause conditions being less expected than relative clauses, although this effect appears two regions after *yorimo*, which disambiguates the clause type toward a comparative clause. Alternatively, it could be that the more complex meaning of the comparative (computing the comparison between cardinalities/degrees of numerosity) gives the interpretation of the comparative clause more processing complexity than relative clauses.

One surprising aspect of these results is that the object relative clause penalty found by other studies was not present in the relative clause conditions in the experiment. Nor was there an effect in the opposite direction. This lack of even a strong numerical difference was especially surprising because the control items from the Ueno and Garnsey (2008) did show an object relative clause penalty (although strangely the numerical effect was present throughout the sentence, contrary to what might be expected). The Ueno and Garnsey items differed from the experimental materials in several respects. First, they used dative topics as the relative clause head, creating a mismatch in case between the relative clause head and the gap site in both object and subject gap conditions. Second, the experimental items used the quantifier *ooku-no* ('many') on the head noun, whereas the Ueno and Garnsey did not. Last, the Ueno and Garnsey (2008) items began with an adjective whereas the experimental items did not. While any of these differences could be the critical one, I would predict that could be the case that the quantifier on the head noun adds complexity in processing the relative clauses, possibly swamping any difference between the object and subject conditions.

4.4 General Discussion

In this chapter, I have presented experimental evidence showing that subject gaps in English comparative clauses are associated with a decline in acceptability as well as a processing penalty as compared to similar sentences with object gaps. After considering accounts based on processing and on grammatical constraints at several levels, I conclude that the best explanation for the subject gap penalty is a syntactic one - that subject gaps in comparative clauses incur a subject island violation, which gives rise to variable degradation in acceptability and in processing difficulty (following a similar argument made for Polish phrasal comparatives in Pancheva and Tomaszewicz (2010)).

The subject island violation account predicts the difficulty of subject gaps in comparatives with *more*-NPs in both subject and object position. However, one observation that is not straightforwardly explained by the subject island account is the diminished subject gap penalty for comparative clauses extraposed from subject position, as examined in Experiment 2. One possibility is that the Comparative Order Hypothesis, introduced in Section 4.2.3, also plays a role in the processing of comparatives. When the comparative clause is in base position, as shown in (225a), the reader or hearer has very little information about the content of the utterance before reaching the gap site. In (225b), the reader already knows along which property the two degrees are being compared before reaching the comparative clause and the gap site. Having this additional information in making predictions about the upcoming material may facilitate processing of the subject gap, diminishing the penalty for the subject island violation.

(225) a. More friends [than talked to the shy girl] were at the party.

b. More friends were at the party [than talked to the shy girl].

Another possible explanation for the decreased penalty for subject gaps in extraposed position could come from the syntax and semantics of the comparative clause. As mentioned in Section 4.1.1, the literature on relative clauses has argued that both raising and matching analyses are required in order to capture the empirical facts. Hulsey and Sauerland (2006) argue that extraposed relative clauses must have a matching analysis, while base position relative clauses in principle can have either analysis. As one piece of evidence for this claim, Hulsey and Sauerland observe that idioms, which must by hypothesis must be interpreted as one clause, are natural with non-extraposed relative clauses (e.g., 226a), but not with extraposed relative clauses (226b, judgment by Hulsey and Sauerland). The same example without an idiom is claimed to be grammatical (226c).

(226) Hulsey and Sauerland (2006):8a-10a

a. Mary praised the headway [that John made].

b. *Mary praised the headway last year [that John made].

c. Mary praised the pot roast yesterday that John made.

Whether a similar syntactic distinction exists between base position and extraposed comparative clauses, and whether such a difference could affect the acceptability of movement from inside a subject, remains a question for future research.

Another remaining question is whether the subject island account is tenable for languages like Japanese, which have been claimed not to have subject islands (although as mentioned above, Jurka et al. (2011) argue against this claim). A more direct test of the subject island effect in Japanese is required in order to provide more solid support for an island account (or to refute such an account). German is another language for which there is debate about the availability of extraction out of subjects. For example, Diesing (1992) proposes that only moved subjects are islands for extraction in German. However, Jurka et al. (2011) found a decrease in acceptability for extraction out of subjects in German as compared to extraction out of objects in both in-situ and moved position, and an additive penalty for extraction out of moved constituents as compared to constituents in situ.

Osborne (2009) observes that in German, there is an asymmetry between comparatives in main and embedded clauses. While subject gaps in comparative clauses are claimed to be acceptable in main clauses (227a), they are claimed to be less acceptable in embedded clauses (227b). The difference between these examples is that in main clauses, verb-second applies, while it does not apply in embedded clauses.

(227) Osborne (2009): 32

a. Mehr Leute *als gegangen sind*, sind geblieben.
more people than gone are are stayed

'More people stayed than left.'

b. ?? weil mehr Leute *als gegangen sind*, geblieben sind
because more people than gone are stayed are
'because more people than left, stayed'

More information is required in order to determine whether this fact is compatible with the island account or would be predicted under any of the other accounts discussed. To my knowledge, no one has directly compared subject and object gaps in these configurations to determine whether there is any subtle penalty for subject gaps in examples like (227a). As mentioned above, we might expect to find a penalty in naturalness or processing complexity for extraction out of subjects even in languages that do not encode subject islands as a grammatical constraint on extraction.

To conclude, further research will be important in providing more definitive support for or against the subject island account. For example, a better understanding of the cross-linguistic picture, and whether the subject gap penalty holds for languages that show varying degrees of acceptability of extraction out of subjects, will be extremely informative to this line of research.

CHAPTER 5

SUBSET COMPARATIVES

5.1 Introduction

The other chapters of this dissertation address questions of the representation and processing of typical comparative and subcomparative structures that compare two degrees (and in many cases, cardinalities or amounts). In this chapter, I will highlight another kind of comparative, which I will call *subset comparatives*. Subset comparatives involve a different relationship between the sets involved in a comparison than typical comparatives do, namely a subset or set membership relationship. Although these constructions have the form of comparatives, their meanings can be understood to be quite different from the comparisons of set cardinalities discussed in previous chapters. Therefore, the existence of subset comparatives may change our view of the form and use of comparatives in natural language. In addition to presenting a puzzle regarding their proper modeling in our framework for the syntax and semantics of comparatives, subset comparatives also provide a new empirical ground for testing hypotheses about the syntactic and semantic processing of comparatives. In this chapter, I will investigate questions of readers' default expectations about the relationship between sets in processing comparatives, and the role of world or conceptual knowledge in the time course of sentence processing.

Comprehending a comparative (more specifically in this case, a subcomparative) like (228) involves the identification of two quantities, or cardinalities, involved in the comparison. In this case, the two quantities are the cardinality of individuals which are dogs and who played fetch, and the cardinality of individuals which are cats and who played fetch. The sentence asserts that the first cardinality is greater than the second. There are several potential formalisations of the meaning of a sentence like (228). One could give the sentence a semantics like in (229a), which would involve the assumption that the complement to *than* is underlyingly clausal. Alternatively, as proposed in Chapter 2, one could propose a representation that does not involve degrees, and assumes no underlying clausal structure in this particular case. This second possible representation is shown in (229b).

(228) More dogs than cats played fetch.

(229) a. $max(\lambda d.d$-many dogs played fetch$) > max(\lambda d'.d'$-many cats played fetch$)$

b. $|\lambda x.\ x$ is a dog & x plays fetch$| > |\lambda y.\ y$ is a cat & y plays fetch$|$

While the semantics in (229b) explicitly compares the cardinalities of two sets of individuals, the semantics in (229a) involves sets of individuals only indirectly. The cardinalities under comparison result from the computation of a degree of *many*-ness. However, one might argue in calculating the degree to be used in the comparison, one must still represent a set of individuals in mind. Comparatives can easily be paraphrased using sets of individuals, for example (228) can be paraphrased as 'the dogs who played fetch outnumber the cats who played fetch'. Comparatives like (228) do seem to have easily accessible sets of individuals, in this case *dogs who played fetch* and *cats who played fetch*, no matter whether or not these sets are represented in the formal semantics of the sentence.

In this chapter, I will examine the possible relationships between the two sets (or the sets that are inferred from the degree description) involved in comprehending comparatives. In some cases, like (228), the sets under comparison can be reasonably assumed to be disjoint. Most individuals at even a young age have the conceptual or world knowledge that no dog is a cat and vice-versa, so the sets being compared in (228) must not overlap. But what about cases like (230)? There is no restriction from our world knowledge that prevents a lawyer from also being a parent. Do comprehenders nonetheless still understand the sets of lawyers and parents in (230) as being disjoint by default? Or, does the processing of examples like (230) easily allow for overlap between the sets? In Figure 5.1, two scenarios are shown, both of which meet the truth conditions of (230). The leftmost grouping shows a greater cardinality of lawyers (represented by 'L') than parents (represented by 'P'). The rightmost grouping shows a greater cardinality of lawyers than parents as well, although this grouping also includes some individuals who are both lawyers and parents.

(230) More lawyers than parents came to the party.

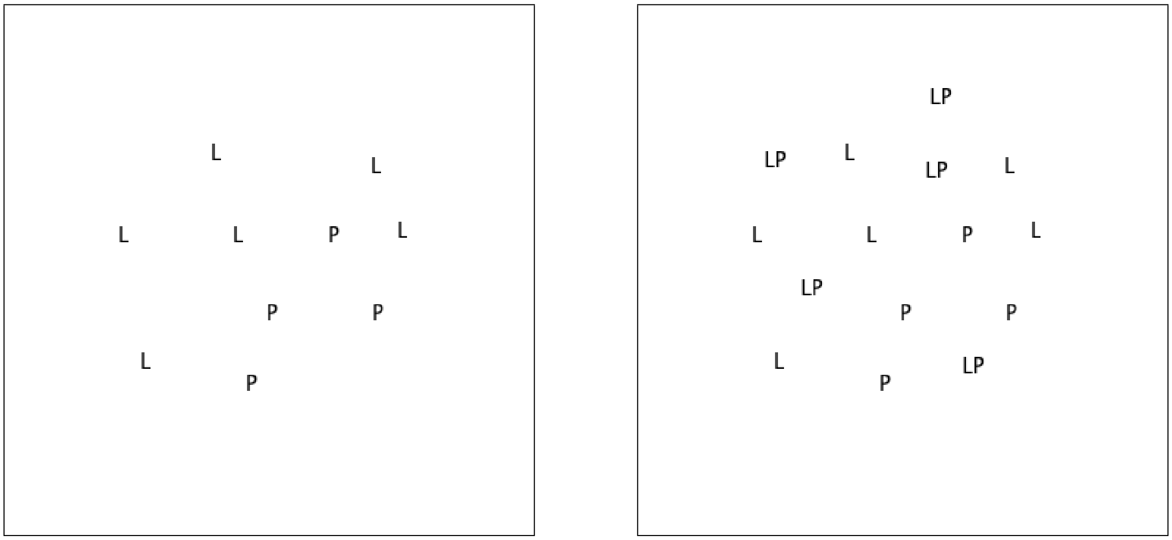


Figure 5.1. Two possible scenarios in which (230) is true. The left group shows six lawyers (represented by 'L') and four parents (represented by 'P') with no overlap. The right panel shows a scenario in which there are eleven lawyers and nine parents, but five of the individuals are both lawyers and parents ('LP').

For sentences like (230), whether or not any overlap between the sets is understood will not make the difference between truth or falsehood of the sentence, because any individuals that are both lawyers and parents do not matter in determining whether one set has a greater cardinality than the other.[1] In Section 5.2, I will introduce a class of comparatives, which I will call *subset comparatives*, wherein there is complete overlap between the sets. Examining subset comparatives, wherein the relationship between sets is of critical importance to the meaning of the sentence as a whole, allows for the collection of data that will address readers' initial assumptions regarding set relationships in comparatives.

5.2 Subset Comparatives

Because the truth-values of examples like (230) are not affected by the presence of individuals who are members of both sets under comparison, it remains in question whether the sets being compared in examples like (230) are typically understood to be non-overlapping, or whether overlap between the sets may be assumed, depending on the particular categories involved. However,

[1]Although, the total number of individuals in each set may factor into the comparison, if the difficulty of comparing two cardinalities depends on the ratio between them (Weber's law). See Chapter 4 for further discussion.

there are examples of comparatives wherein the sets *necessarily* overlap. In such examples, the set described by the standard of comparison is a subset of the set described by the associate of comparison. For this reason, I will refer to such examples as *subset comparatives*. Some attested examples of subset comparatives (drawn from an internet search) are shown in (231-233). In some examples, the subset relationship is apparent from world knowledge or conceptual knowledge. In (231), many adults would know that Jennifer Aniston is a member of the set of actresses, making the subset relationship apparent. However, subset comparatives do not require the subset relationship to be based on world knowledge. For example, even though empty seats aren't inherently a problem (they might be a good thing if one is looking for a place to sit), in example (232) empty seats must be understood to be one of the problems that are posed by Yankee stadium. Subset comparatives frequently occur with *just* following *than*, but *just* seems not to be strictly necessary.[2] The role of *just* in subset comparatives will be discussed further in Section 5.6.

(231) Joan Collins meant to insult **more actresses than just Jennifer Aniston**.

(Sabrina Brody, LA Examiner, www.examiner.com, 25 October 2010)

(232) Yankee stadium poses **more problems than just empty seats**.

(Brenden Monroe, www.bleacherreport.com, 23 April 2009)

(233) (Talking about daytime running lights)

I've noticed that **many more cars than just GMs** have them now, though (some Hondas, Fords, etc.)

(http://www.gminsidenews.com/forums/f19/gm-drls-daytime-running-lights-66440/index3.html)

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[2]Native speakers of German and Dutch (as well as some English speakers) have suggested that an element like *just* is required or strongly preferred. The typical such element in German is *nur*, which corresponds to English *only/just*. Example (i) shows a German subset comparative.

i. German (example due to Martin Walkow):

Mehr	Computer	als	nur	Laptops	wurden	gestohlen.
more	computers	than	only	laptops	were	stolen.

' More computers than just laptops were stolen.'

The complement to *than* in a subset comparative can be a bare plural, similar to a subcomparative like (234), repeated from (228). In example (235), the complement to *than* is *poodles*, which are a subset of the set of dogs.

(234) More dogs than cats played fetch.

(235) More dogs than poodles played at the park.

Subset comparatives, however, can also have a full-DP complement to *than*, which is not possible with typical subcomparatives. Example (236) shows that DP-internal subcomparatives are ungrammatical with a DP complement to *than*, while (237) shows that this is possible when the complement to *than* is a subset of the associate of comparison (*dogs*).

(236) *More dogs than a cat played fetch.

(237) More dogs than a poodle played at the park.

Examples like (233) suggest that bare plural complements to *than* in subset comparatives may be interpreted as *kinds* (as per Carlson, 1977b) rather than individuals. Knowing that full-DP complements to *than* are possible for subset comparatives, we might predict that the distinction between interpreting a bare plural complement to *than* as individuals or kinds may be due to an ambiguity as to whether the bare plural is interpreted as a bare NP (leading to an individual interpretation) or a DP (leading to a kind interpretation).

5.3 Subset comparative syntax

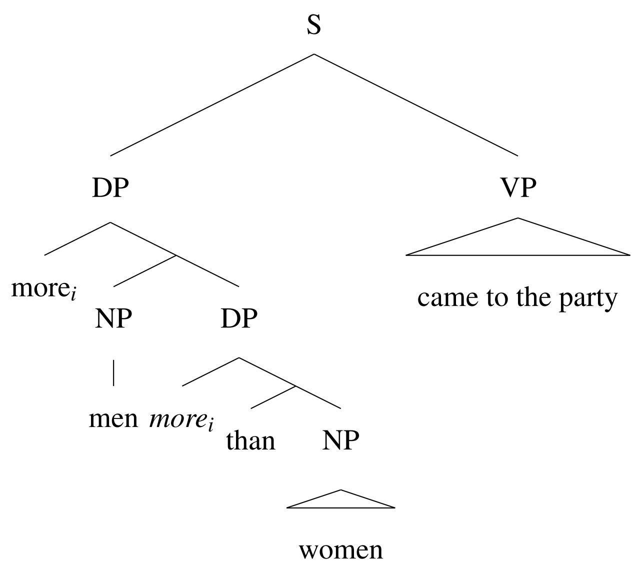
While subset comparatives have the form of comparatives, an obvious question is whether they have the same syntactic and semantic representations as typical comparatives. In this section, I will discuss the syntactic representation of subset comparatives, before addressing their semantic representation in Section 5.4. The appropriate syntactic representation for subset comparatives may depend on the form of the complement to *than*. When the complement to *than* is a bare plural, as in (238), subset comparatives bear a superficial similarity to so-called DP-internal subcomparatives like (228), repeated as (239).

(238) More birds than eagles flew over the conservation area.

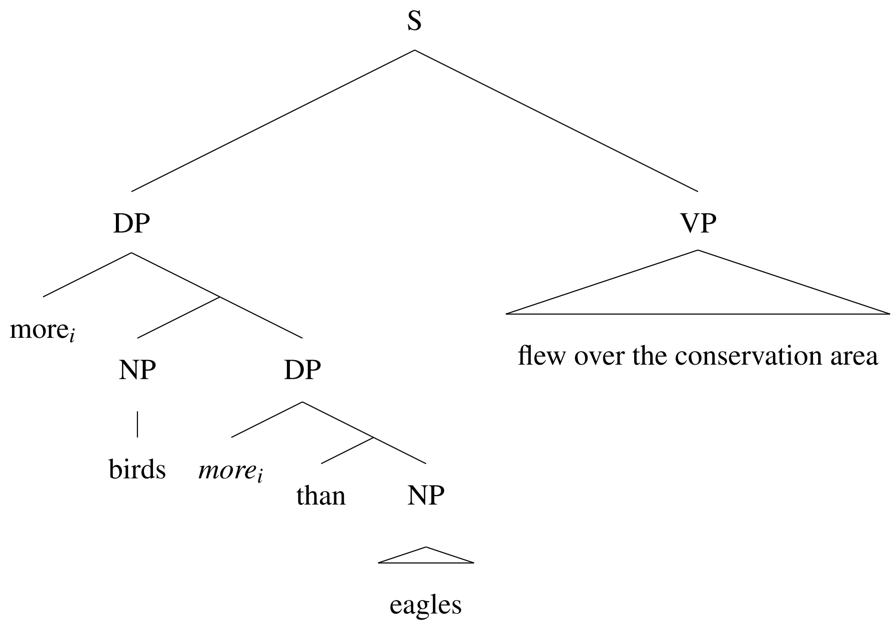
(239) More dogs than cats played fetch.

In Chapter 1, I discussed the structure and semantics for DP-internal subcomparatives like (239), and concluded that the best hypothesis for their structure is the DP-shell structure of Izvorski (1995a) (following the meaning of Keenan, 1987). This structure is shown in (240). Izvorski (1995a) provides an analysis for examples like (239) based the movement of *more* from a lower DP to a higher DP, creating a DP-shell structure. The movement is motivated by selectional restrictions at each DP level. The lower *more* selects specifically for a *than*-constituent, and the higher *more* ensures that the associate in these cases is a bare plural NP. The DP-shell structure as applied to a subset comparative is shown in (241).

(240)



(241)



While the DP-shell structure can be employed in subset comparatives with bare plural complements to *than*, we also know that complements to *than* in subset comparatives can be full DPs, such as proper names or DPs with overt determiners. Because it selects for a bare NP as complement to *than*, the structure shown in (240) cannot straightforwardly underlie subset comparatives like (237), repeated as (242).

(242) More dogs than a poodle played at the park.

Examples like (242), however, bear a similarity to what I will call Attributive NP-comparatives.[3] Attributive NP-comparatives like (243), as observed by Bresnan (1973), come with a built-in subset requirement. For example, the complement of *than* in (243) must have the property of being a man, as demonstrated by the infelicity of (244).

(243) A taller man than my father came to the party.

(244) # A taller man than **my mother** came to the party.

Lechner (2001) (see also Matushansky, 2002) provides analyses for Attributive NP-comparatives that capture the subset requirement by proposing that the associate NP (e.g., *man*) is covertly present

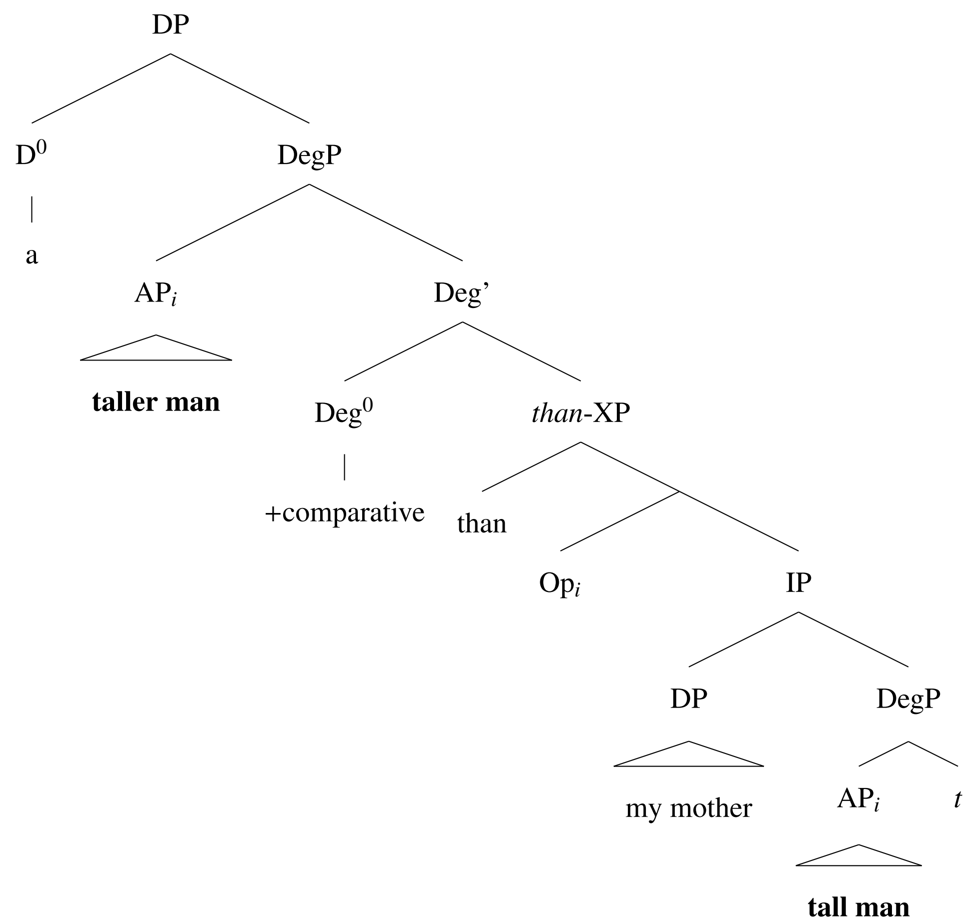
[3]These examples have also have been called simply NP-comparatives, but I add the 'attributive' distinction to distinguish them further from DP-subcomparatives.

in the phrase headed by *than*. This analysis claims that (243) has the interpretation shown in (245), but that all of the material except for *my father* in the *than*-clause is unspoken.

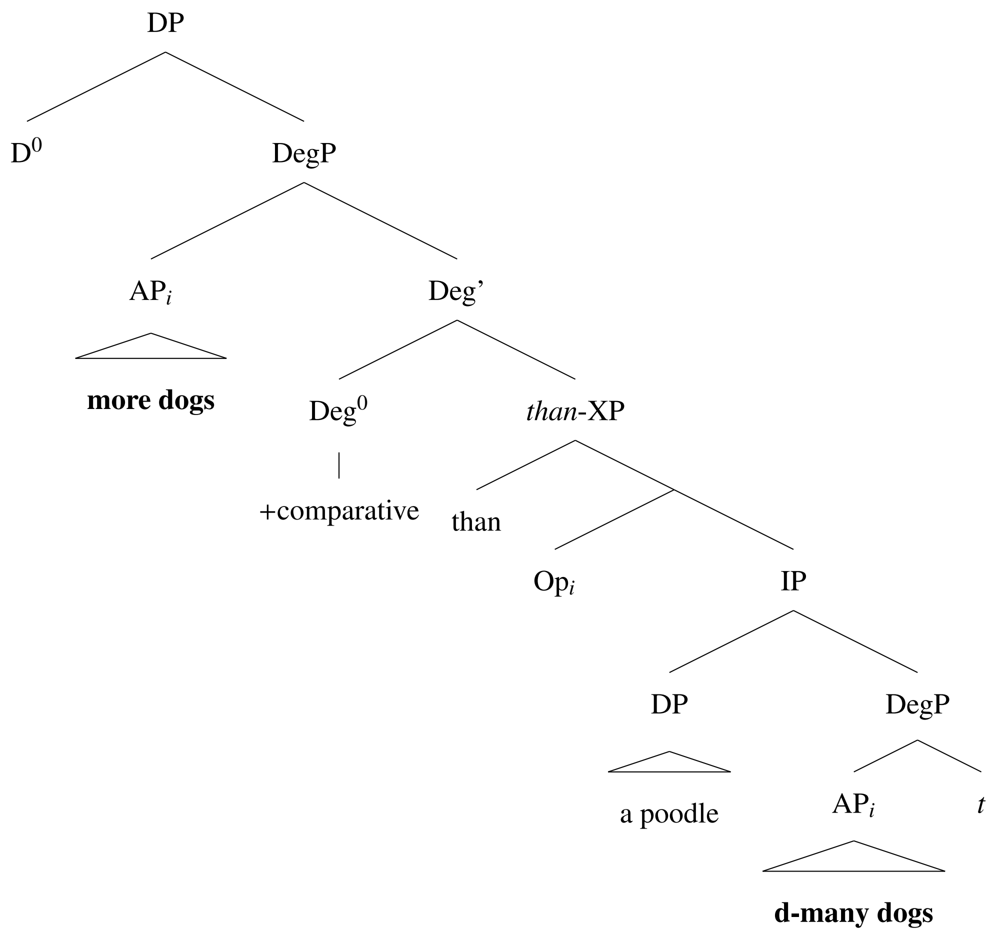
(245) A taller man than my father ~~*is a d-tall man*~~ came to the party.

Lechner (2001) proposes that the subject DP in (243) has the structure in (246), where the AP *tall man* is included in the *than*-constituent, called the *than*-XP by Lechner. Lechner's structure for Attributive NP-comparatives is applied to a subset comparative example in (247).

(246)



(247)



Due to the similarities of subset comparatives to both DP-internal subcomparative and Attributive NP-comparative structures, let us assume for the moment that both structures are possible for subset comparatives: a DP-shell subcomparative structure for those subset comparatives with bare plural complements to *than* (241), and an Attributive NP-comparative structure for those subset comparatives with full-DP (or kind-denoting bare plural) complements to *than* (247).[4] Crucially, there is an important asymmetry between these two structures. The DP-internal subcomparative structure allows for either contrastive (typical) or subset comparatives, while the Attributive NP-

[4]One alternative view would be to say that all subset comparatives underlyingly have the Attributive NP-comparative structure, and that in the case of bare plural complements to *than* the subset comparatives are only superficially similar to DP-internal subcomparatives. However, it is this surface similarity that is important in the design of Experiment 1. Deciding whether subset comparatives have one or two possible underlying structures will depend on a further investigation of the kind vs. individual interpretation of bare plural complements to *than* in subset comparatives. If bare plurals routinely have individual interpretations (i.e., they are interpreted as true plurals), then a theory that keeps the DP-subcomparative structure would be supported. If it turns out that bare plurals following *than* are interpreted as kinds, then subset comparatives could be reduced to the Attributive NP-comparative structure. However, in Section 5.9, I will argue for a theory that in fact favours the DP-shell structure over the Attributive NP-comparative structure.

comparative structure requires that a subset relationship hold between the complement of *than* and the associate of comparison. This asymmetry gives rise to a processing prediction that a full-DP complement to *than* that is a member of the set described by the associate of comparison may disambiguate toward a subset comparative interpretation. However, a bare plural following *than* may not signal the reader or listener to a subset interpretation immediately. This processing implication is tested in Experiment 1, presented in Section 5.5.

5.4 Subset comparative meaning

In the above section, I presented two syntactic analyses for subset comparatives: one for those with bare plural complements to *than*, and one for those with full DPs. These analyses seem to capture the desired properties for the basic architecture of subset comparatives, but do they generate the right meaning? The semantics for DP-internal subcomparatives developed in Chapter 1 proposes that sentences like (228, repeated as 248a) have the semantics in (248b), where two cardinalities are compared. This meaning asserts that the cardinality of the set of entities that are both dogs and who played fetch is larger than the cardinality of the set of entities who are cats and who played fetch.

(248) a. More dogs than cats played fetch.

b. $|\lambda x.\ x$ is a dog & x played fetch $|$ > $|\lambda x.\ x$ is a cat & x played fetch $|$

Applied to a subset comparative as in (249), this semantics gives rise to the meaning that the cardinality of birds that flew over the conservation area is larger than the cardinality of eagles that flew over the conservation area. This semantics is shown in (249b). Intuitively, sentence (249a) means that in addition to at least one eagle, some non-eagle birds flew over the conservation area. While this intuitive meaning entails the semantics in (249b), that the set of birds that flew over the conservation area is larger than the set of eagles that flew over the conservation area, subset comparatives include at least one piece of meaning that is not captured by (249). We understand from the subset comparative that it is true that at least one eagle flew over the conservation area, and it is not clear that the DP-internal subcomparative semantics gives rise to this interpretation. Example (248), for example, may be true even if no cats played fetch, as long as at least one dog played.

(249) a. More birds than eagles flew over the conservation area.

b. $|\lambda x.\ x$ is a bird & x flew over the conservation area $|$

$> |\lambda x.\ x$ is an eagle & x flew over the conservation area $|$

As mentioned above, Attributive NP-comparatives have a structure (and therefore a semantics) that requires the subset relationship between the complement to *than* and the associate of comparison. The semantics for example (243), repeated as (250a), is shown in (250b).

(250) a. A taller man than my father came to the party.

b. $max(\lambda d.$ a d-tall man came to the party) > $max(\lambda d.$ my father is a d-tall man).

Applied to the subset comparative in (251a), the Attributive NP-comparative analysis would give the sentence a meaning that at least one non-eagle bird flew over the conservation area. Again, this meaning is consistent with the intuitive meaning of the sentence, but doesn't capture the whole meaning. The presupposition that an eagle flew over the conservation area does not follow from the semantics in (251b). The Attributive NP-comparative (250a) does not convey that my father was at the party, only that someone who is taller than him was at the party.

(251) a. More birds than an eagle flew over the conservation area.

b. $max(\lambda d.\ d$-many birds flew over the conservation area) > $max(\lambda d.$ an eagle is d-many birds).

The interpretation that the predicate of the clause in which the comparative appears, in this case the property of having flown over the conservation area, is true of the complement of *than* seems to be a characteristic of subset comparatives. This part of the subset comparative meaning does not follow from extending existing analyses of similar structures. One possibility for the source of this meaning is that the unifying element in subset comparatives is *just*, or an element like *just*, which provides the meaning missing from the semantics of DP subcomparatives and Attributive NP-comparatives. In Section 5.6, I discuss this idea further and show evidence that this part of the meaning of a subset comparative is a presupposition rather than an entailment. I will descriptively define this unifying aspect of subset comparative meaning the *Subset Comparative Presupposition*, defined in (252).

(252) *Subset comparative presupposition (SCP): first version*

In subset comparatives, the predicate of the clause in which the comparative appears is true of the complement to *than*.

In the two previous sections, I have discussed hypotheses regarding the syntactic and semantic representation of subset comparatives. With this start toward a theory of subset comparative representations, we can now turn to questions of how representations of subset comparatives are built and interpreted incrementally. Section 5.5 will introduce hypotheses as to how and when readers identify subset comparatives during on-line sentence processing.

5.5 Subset comparative processing

Subset comparatives provide an empirical ground on which to test hypotheses regarding the interpretation of the relationship between sets in comparatives. As discussed in the introduction to this chapter, assessing the truth or falsehood of sentences with comparatives of the form *more NPs than NPs* involves making a comparison between two sets. Depending on the content of the sentence, the sets may be interpreted as disjoint based on the lexical/conceptual content of the comparative, for example the dogs and cats in example (228). Our conceptual knowledge tells us that the dogs and cats being compared do not overlap. However, in examples such as (230), there is no lexical or conceptual constraint against the sets of lawyers and parents overlapping - it is easy to imagine one individual being a member of both sets. However, it is possible that in comparatives, a disjoint relationship between the two sets under comparison is *preferred*, or interpreted by default, even when it is not required based on conceptual constraints. The case of subset comparatives is special because, in these cases, the set that is the complement to *than* is required to be a subset of the set that is the associate of comparison. In this chapter, I will address the question of whether, in processing comparatives, there is an initial expectation for contrasting, disjoint sets, or whether the interpreted relationship between sets depend primarily on bottom-up lexical/conceptual information. If there is an initial preference for disjoint sets, then it would predict processing difficulty for subset comparatives (at least those without *just*) due to the requirement for overlapping sets. This hypothesis, which I call the *Contrast Preference Hypothesis*, is defined in (253).

(253) *Contrast Preference Hypothesis:*

When parsing and interpreting a comparative construction, readers initially impose a contrastive (and likely disjoint) relationship between the sets under comparison. Unless there is structural information indicating a non-contrastive relationship between the sets, a lexical/conceptual subset relationship will be not be immediately integrated.

A competing hypothesis to the Contrast Preference Hypothesis would be a bottom-up theory proposing that readers integrate conceptual or contextual information immediately, and that it is this information rather than structural or semantic expectations that drives the interpretation of the sentence. Such a theory would predict immediate detection of a subset relationship between the complement to *than* and the associate of comparison because of the relationship between the lexical meanings of the nouns (e.g., *eagle- bird*). Under this theory, a subset comparative interpretation would immediately be computed upon encountering a subset complement to *than*, and no additional difficulty due to revision toward a subset interpretation would be predicted. This hypothesis is defined in (254).

(254) *The Immediate Recognition Hypothesis:*

When parsing and interpreting a comparative construction, readers recognize and interpret a subset relationship between the complement of *than* and the associate of comparison through the immediate integration of world, conceptual and contextual knowledge.

The Contrast Preference Hypothesis predicts a difference in processing between subset comparatives that have a bare plural NP complement to *than*, and those that have a full-DP complement to *than*. Bare plural complements to *than* are licensed under a subset interpretation (255) or a contrastive interpretation (256). Therefore, while processing a sentence like (255) it is possible that, if the integration of the conceptual knowledge that laptops are computers is not immediate, that the comparative could be initially processed as contrastive. This would mean that any effect of revision toward a subset interpretation would occur only when the conceptual knowledge relationship between laptops and computers is noticed, which by hypothesis would be at a delay from initially encountering the complement of *than*.

(255) More computers than laptops got stolen from the IT department.

(256) More cell phones than laptops got stolen from the IT department.

Full-DP complements to *than*, however, are only licensed under a subset interpretation and not under a contrastive interpretation. Compare (257), a subset comparative, to its anomalous contrastive counterpart (258). With respect to the Contrast Preference Hypothesis, a full-DP following *than* could serve as a *syntactic* signal during processing that the expectation for contrast must be revised.[5] Contrary to the Contrast Preference Hypothesis, the Immediate Recognition Hypothesis relies on lexical/conceptual information over syntactic or compositional-semantic cues, and so would not predict a difference between the bare plural and full-DP types of subcomparatives (beyond low-level factors like length, etc.).

(257) More computers than a laptop got stolen from the IT department.

(258) #More cell phones than a laptop got stolen from the IT department.

In order to test whether readers use top-down expectations or bottom-up lexical information integrated with world and conceptual knowledge in the processing of comparatives, a study of eye-movements during reading was carried out. Eye movement data allows for investigation of processing difficulty across the content of the sentence, which will allow us to address the time course predictions of the two hypotheses under consideration.

5.5.1 Experiment 7

Experiment 7 was carried out in order to test whether syntactic-semantic prediction or lexical/conceptual properties take priority in the processing of comparatives. The experiment studied eye movements while reading sentences like (255-256) and (257-258) to determine whether the form of the complement to *than* had an influence in the timing and magnitude of any effect of revision from an initial contrastive expectation toward a subset interpretation.

5.5.1.1 Method

5.5.1.1.1 Materials Twenty-four item sets like the one in (259) were constructed and counterbalanced across participants (Appendix A lists all experimental items). The regions of analysis that will be discussed in the Results section are numbered and delimited by |. Two factors were varied in the experiment. The Type of comparative was varied between contrastive and subset comparatives by choosing words that were in a conceptual subset relationship (e.g., *laptop* to *computer*) or not

[5]Of course, there is the possibility that a full DP following *than* could be the subject of a comparative clause. This possibility will be discussed following the presentation of the experiment.

(e.g., *laptop* to *cell phone*). In a separate questionnaire study, 34 subjects rated the noun pairs, counterbalanced across two lists, in terms of how well NP_2 fit into the category of NP_1 on a scale from 1 (not at all) to 5 (very well). Subjects were given an example of how to answer the question (*"if the pair were sneakers- shoes, you would rate how well sneakers fit into the category of shoes"*) but no examples of good or bad fits were given. Subset pairs rated on average 4.81, while non-subset pairs had an average rating of 2.3. This difference was highly significant ($p < .001$). The difference between contrastive and subset comparative was made by varying the associate of comparison so that the region of interest in the complement to *than* contained the same lexical item across conditions.

(259) a. During the theft,$_1$| more computers$_2$| than$_3$| laptops$_4$| got stolen$_5$| from the IT department. $_6$|

b. During the theft,$_1$| more cell phones$_2$| than$_3$| laptops$_4$| got stolen$_5$| from the IT department. $_6$|

c. During the theft,$_1$| more computers$_2$| than$_3$| a laptop$_4$| got stolen$_5$| from the IT department. $_6$|

d. During the theft,$_1$| more cell phones$_2$| than$_3$| a laptop$_4$| got stolen$_5$| from the IT department. $_6$|

The second factor that was varied is the form of the Complement to *than*. In two conditions (259a-b), the complement to *than* was a bare plural, and in two conditions (259c-d) the complement to *than* was a singular indefinite DP. The fully crossed design of the experiment means that one condition, the contrastive, indefinite condition (259d), was an anomalous sentence. The implications of including this condition will be discussed further in the Results and Discussion sections.

5.5.1.1.2 Procedure Thirty-six undergraduates at UMass Amherst participated individually for psychology course credit. All subjects were native English speakers with normal or corrected-to-normal vision, and were naive to the purpose of the experiment. Subjects read sentences presented on an Iyama CRT Monitor in 11pt Monaco font. They were instructed to read the sentences naturally, making sure they understood what they were reading. Subjects' eye movements were recorded using an Eyelink 1000 eyetracker (SR Research, Toronto, Canada), which has a sampling rate of 1000Hz, interfaced with a PC. Viewing of sentences was binocular, but only one eye was monitored.

Subjects were seated approximately 60cm from the computer screen. At this viewing distance, 3.18 characters of text were subtended by 1° of visual angle. At the beginning of the experiment and occasionally between experimental trials, subjects' eye gaze was calibrated using a 3-point calibration procedure. The experiment was implemented using EyeTrack software (http://www.psych.umass.edu/eyelab/software/).

The experimental items were randomized and intermixed with 86 sentences from unrelated experiments. The non-experimental trials included some sentences containing an anomalous/implausible word. Subjects were instructed that some of the sentences they read might be "weird." On approximately 22% of trials, subjects were presented with a comprehension question following the experimental sentence.

5.5.1.2 Results

Prior to statistical analysis, 9% of trials were removed due to track losses. Fixations longer than 1000ms on a critical region of text resulted in deletion of a trial; long fixations elsewhere were deleted. Short fixations of less than 80ms were merged with a neighbouring fixation if one was within one character, or were deleted. The mean comprehension accuracy was 83%. Means for all eye movement measures are shown in Table 5.1, and LME model parameters are provided in Appendix C. The random effects structure for the statistical models included, for subjects and items, random intercepts and random slopes for each of the experimental manipulations (Type and Complement) and for their interaction. In some instances, as indicated in the appendix, the model did not converge with this maximal random effects structure, and the random effects for interactions between Type and Complement were removed. Both factors (Type and Complement) were centered prior to statistical analysis. The critical regions for analysis are Regions 4-6, beginning from the complement to *than* until the end of the sentence. I will discuss First Pass Time, Go-Past Time and Regressions Out for these regions as well as Region 3 (*than*), in which it was possible that parafoveal-on-foveal effects could occur (see Drieghe, 2011 for discussion). However, Region 3 only contains the standard marker *than*, a function word that is often skipped, so the models for this region are based on fewer data points than the other regions. Region 2 showed a significant effect of Type for First-Pass Time and Go-Past Time such that the contrastive comparative conditions had longer times than the subset conditions. However, because the subset and contrastive conditions contained different words on this region, these effects are likely to be due to differences in word length, frequency or other lexical factors.

	Subset		No Subset	
	Bare Plural	Sg. Indefinite	Bare Plural	Sg. Indefinite
First Pass Time (ms)				
Region 1	444	470	439	404
Region 2	444	427	492	483
Region 3	285	275	282	264
Region 4	283	332	287	362
Region 5	340	353	338	346
Region 6	838	952	884	889
Go-Past Time (ms)				
Region 1	444	470	439	404
Region 2	511	510	568	586
Region 3	330	326	342	283
Region 4	344	480	355	543
Region 5	366	459	365	429
Region 6	1495	1402	1297	1330
% Regressions Out				
Region 2	12	13	11	14
Region 3	11	12	9	3
Region 4	18	37	24	31
Region 5	3	13	5	13
Region 6	38	24	28	26

Table 5.1. Means for eye-movement measures, Experiment 7

5.5.1.2.1 First-Pass Time Figure 5.2 shows the pattern of First-Pass Times in all regions. In First-Pass Time, there were no significant effects of the experimental factors in Region 3 (*than*). In Region 4, the complement to *than*, singular indefinite DPs showed longer times than bare plurals (Estimate = 62.06, SE = 13.24, t = 4.69). Because the indefinite DPs were longer than the bare plurals, containing two words as compared to one, this effect could be merely due to the length of the region. There were no other significant effects for Region 4, and no significant effects in Regions 5. Similarly, no predictors were significant for the initial model run for Region 6. For all models, Trial Sequence was included as a fixed effect to capture any speed-up or slowdown in reading over the course of the experiment. However, for Region 6, the final region of the sentence, visual inspection of the data showed that the pattern of data was affected in a more specific way. Figure 5.3

shows a split between the first half and second half of experimental trials. From this figure, we can see that for contrastive comparatives, where the bare plurals initially had longer First-Pass Times than singular indefinites, this pattern reversed later in the experiment. For subset comparatives, the singular indefinite condition had longer First-Pass Times than the bare plural condition, and that held for both halves of the experiment, although the difference was smaller for the last half of experimental trials. In order to test for interactions between the experimental manipulations and Trial Sequence, a new model was run that included interactions between Trial Sequence and the other factors. This model showed a significant three-way interaction (Estimate = -27.77, SE = 8.76, t = -3.17).

5.5.1.2.2 Go-Past Time Figure 5.4 shows the pattern of results for Go-Past Time. There were no significant effects in Region 3. In Region 4, there was again an effect of Complement (Estimate = 156.96, SE = 25.81, t = 6.08) such that singular indefinites had longer Go-Past Times than bare plurals. This effect extended to Region 5 as well (Estimate = 77.42, SE = 24.75, t = 3.13). On Region 6, there were no significant effects; this was true even when the statistical model was augmented with interactions between the experimental manipulations and Trial Sequence.

5.5.1.2.3 Regressions Out Figure 5.5 shows the pattern of results for Regressions Out of a region on the first pass. On Region 3 (*than*), there was a marginally significant interaction between Type and Complement such that the contrastive, singular indefinite condition had the smallest proportion of trials with a regression in this region (Estimate = 2.17 , SE = 1.13, z = 1.92, p = .055), and overall subset comparatives had more regressions out of this region (Estimate = 1.11, SE = 0.54, z = 2.048 , p = .041). On Region 4, there was a significant effect of Complement, with singular indefinites having more regressions than bare plurals (Estimate = .89 , SE = .21, z = 4.27, p < .001). There was also a marginally significant interaction such that the subset, bare plural condition had fewer regressions out than the contrastive, bare plural condition (18% vs. 24%), but the reverse was true for the two singular indefinite conditions (37% for the subset, indefinite condition and 31% for the contrastive, indefinite condition) (Estimate = .65, SE = .38 , z = 1.72, p =.085). Region 5 showed an effect of Complement such that there were fewer regressions out of the bare plural conditions than the singular indefinite conditions (Estimate = 1.30, SE = .34, z = 3.78, p < .001). On the final region of the sentence, Region 6, Trial Sequence affected the proportion of Regressions

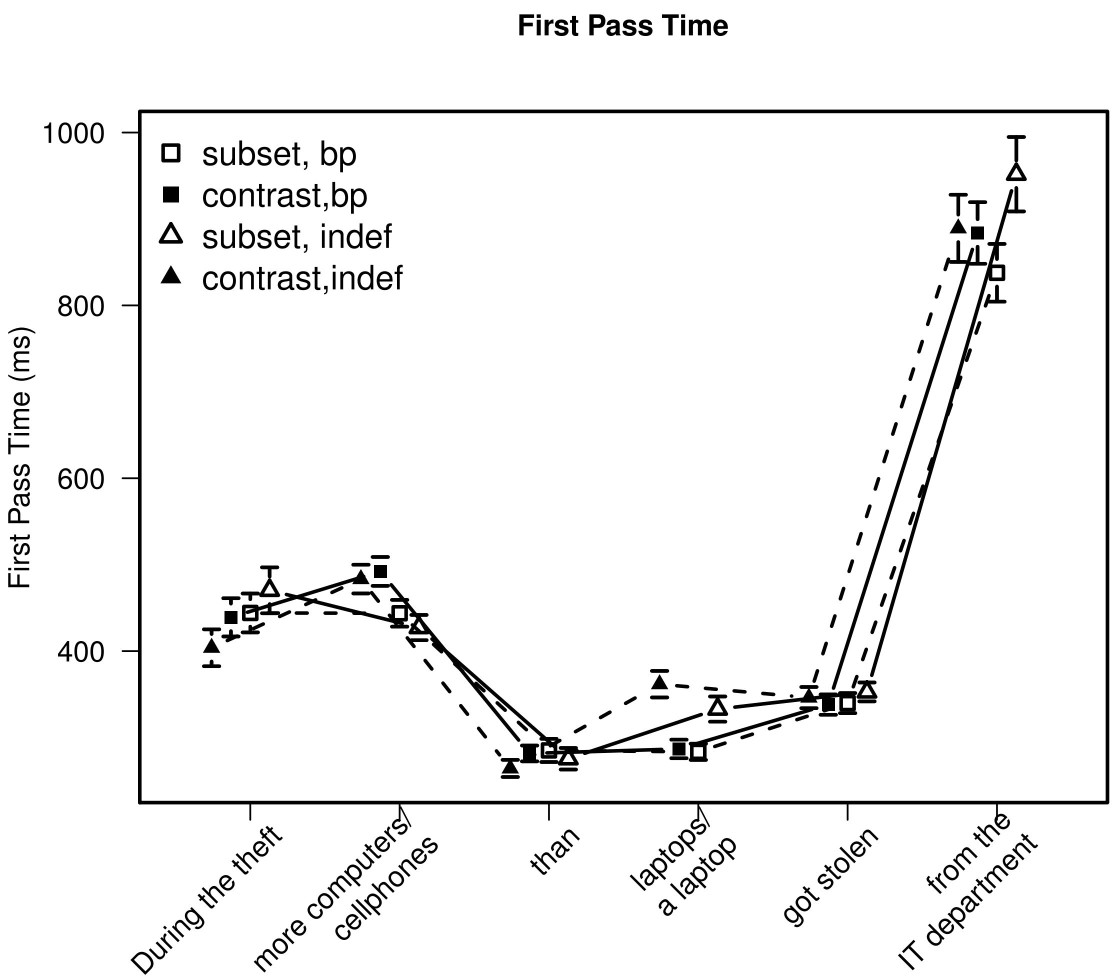


Figure 5.2. First Pass Times by region, Experiment 7

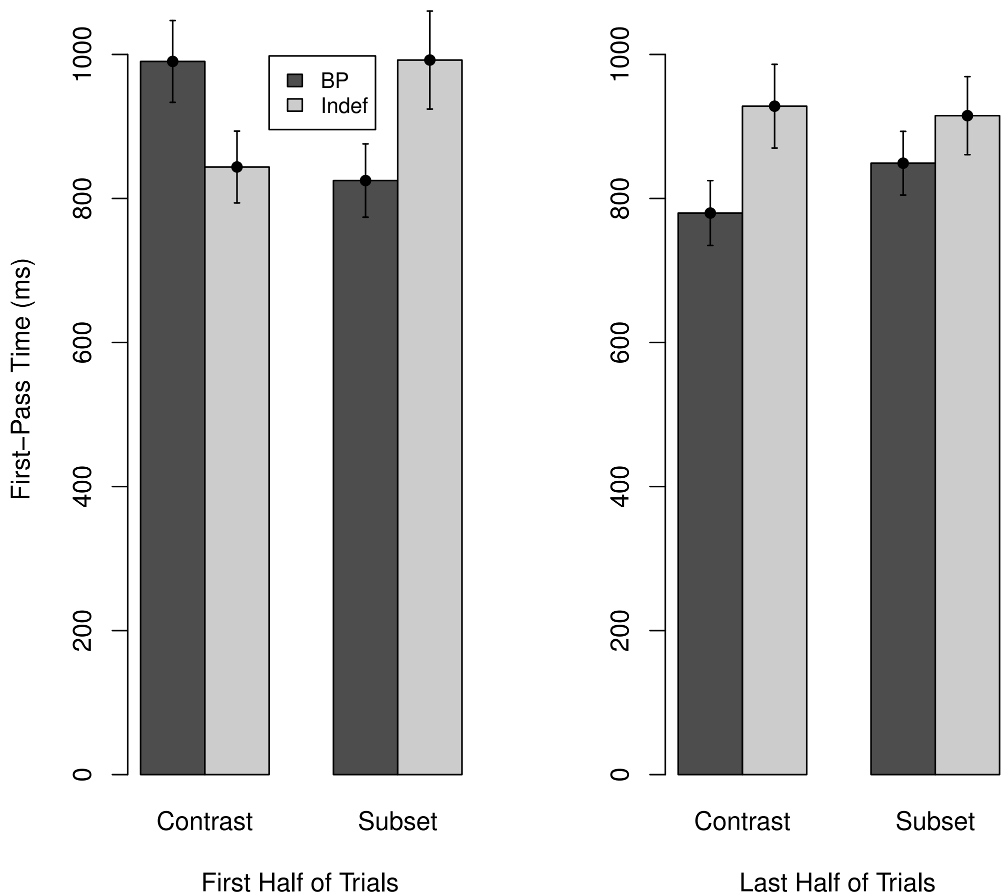


Figure 5.3. First Pass Times on Region 6, split into early and late portions of the experiment.

Out in a way that mirrors the interaction seen in First-Pass Time. On this region, the subset, bare plural condition had the largest proportion of Regressions Out overall. Figure 5.6 shows that this held for trials from both the first and second halves of experimental trials, although the difference between this condition and the others was smaller in the latter half of trials. For the contrastive comparatives, however, while initially there were numerically more regressions out of the singular, indefinite condition, this pattern reversed in the second half of trials. Statistically, the pattern of results for Regressions Out of Region 6 showed a three-way interaction between Type, Complement and Trial Sequence (Estimate = .11, SE = .056, z = 1.97, p = .049). The interactions between Type and Complement, Type and Trial Sequence, and Complement and Trial Sequence were also

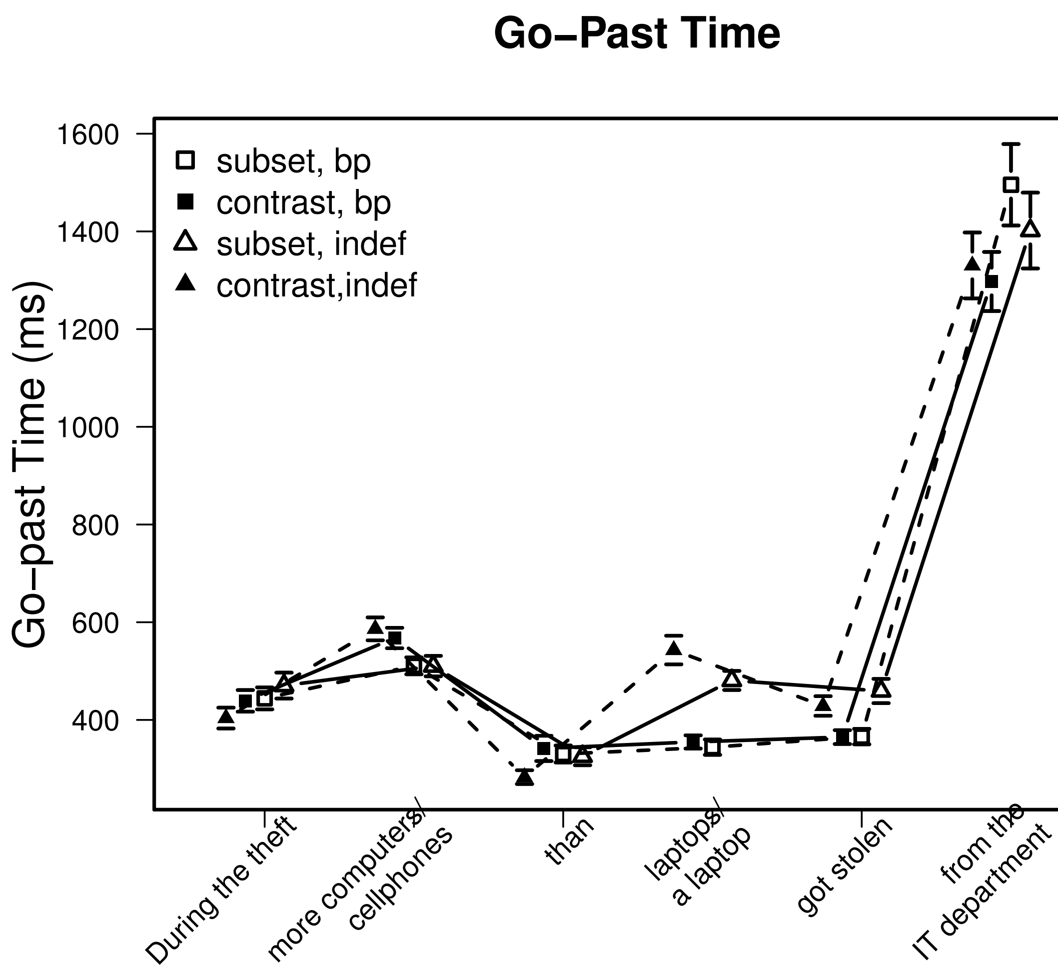


Figure 5.4. Go-Past Times by region, Experiment 7

significant (see appendix for model parameters), as was the effect of Complement. The effect of Trial Sequence alone was marginally significant.

5.5.1.3 Discussion

The results of Experiment 1 bear out a prediction of the Contrast Preference Hypothesis. This hypothesis predicted that readers would initially interpret the subset, bare plural condition as contrastive, and because the form of the complement to *than* was not inconsistent with a DP subcom-

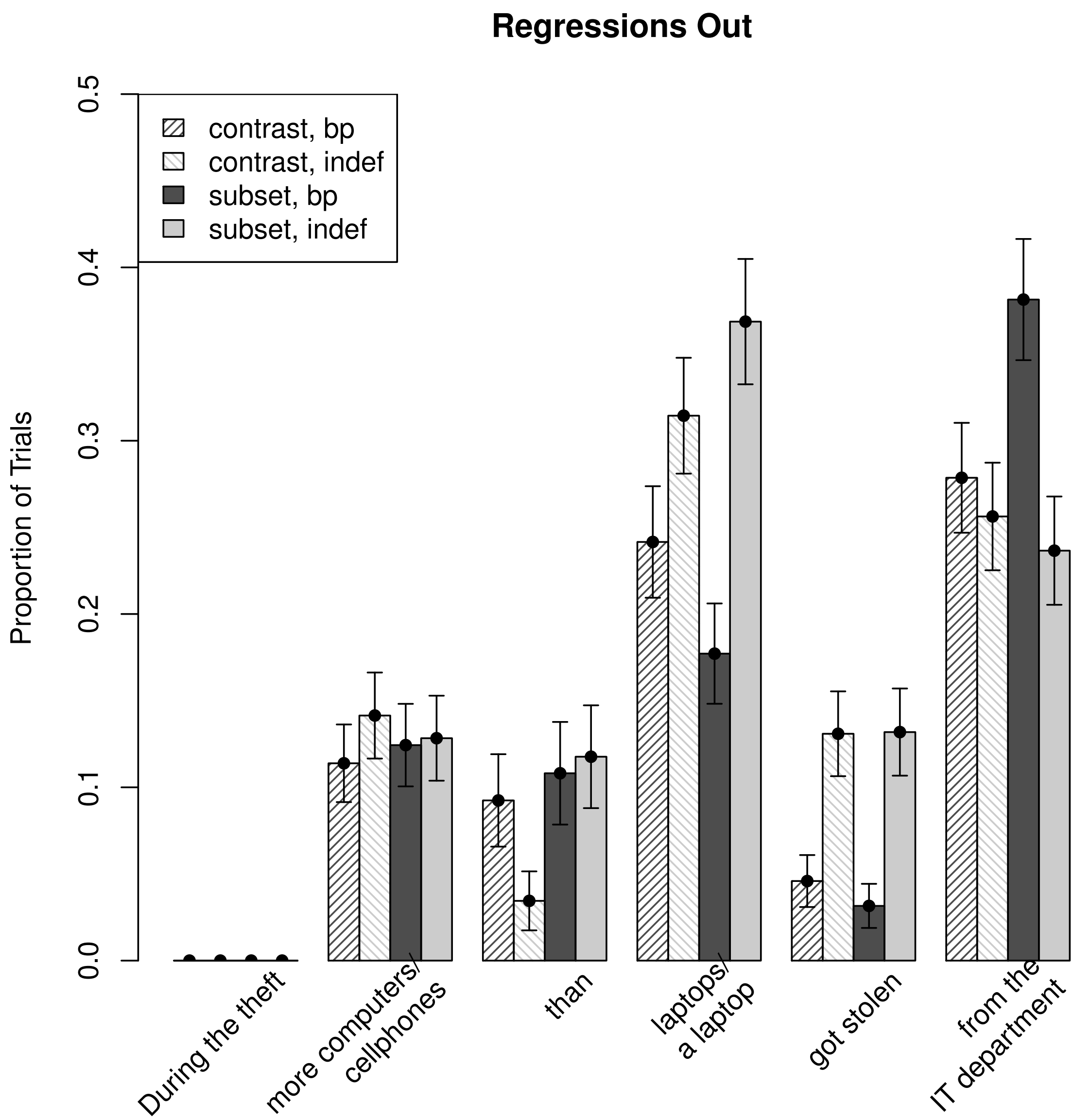


Figure 5.5. Regressions Out by region, Experiment 7

parative interpretation, the realization that there was a subset relationship between the complement of *than* and the associate of comparison would be delayed until a later stage of comprehension. This effect is seen best in the proportion of Regressions Out of the final region of the experimental materials, where there was an interaction such that the bare plural, subset condition had the greatest proportion of trials with a regressive eye movement. Numerically, this condition also had the longest Go-Past Times.

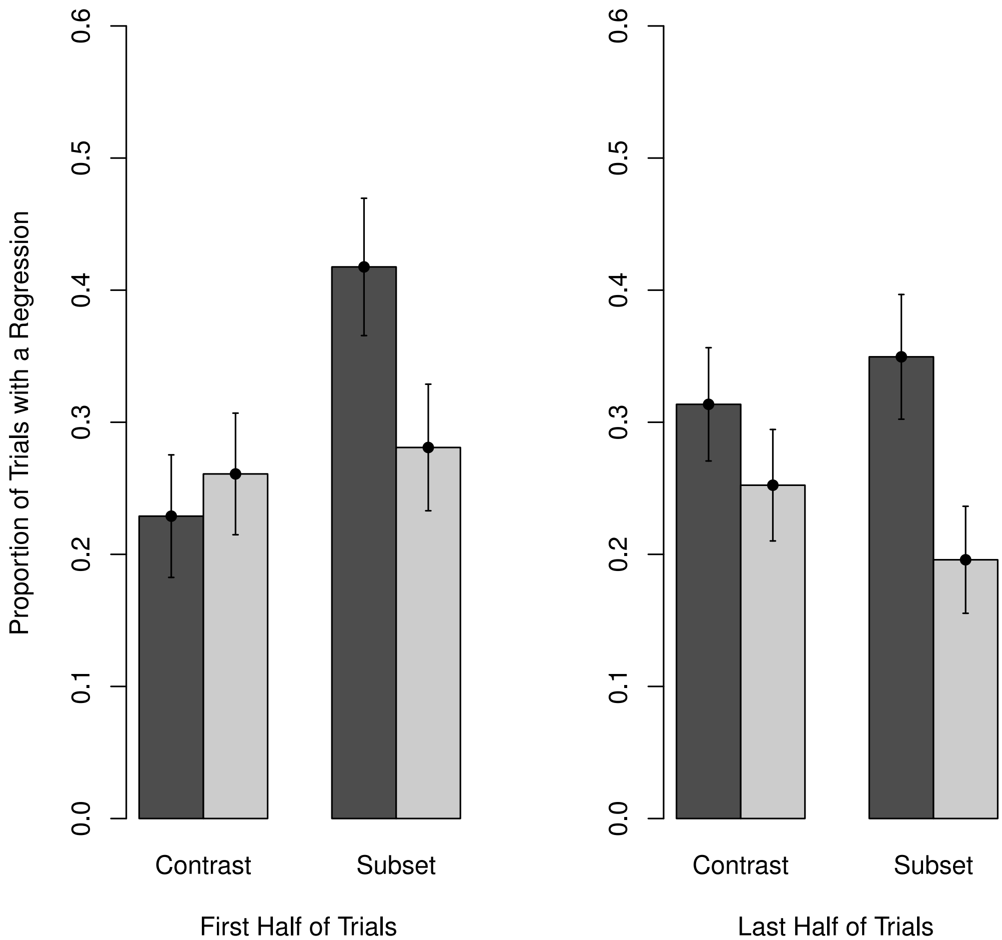


Figure 5.6. Regressions Out split into early and late portions of the experimental trials, Experiment 7.

In this experiment, the results for the conditions with singular indefinite complements to *than* are more difficult to interpret. On Region 4, conditions with singular indefinite complements to *than* had longer First-Pass Times and Go-Past Times as well as more Regressions Out than the bare plural conditions. The effect of Complement on this region could be due to an unexpected form as a complement to *than*, but it could also be due to the difference in length and number of words (two versus one) in the region. However, this effect continued on the subsequent region (Region 5) in Regressions Out, which would be unexpected if the effect were merely due to the small difference in length on Region 4. Another unexpected aspect of the results is that the two singular indefinite conditions patterned together, when one had a licensed (if dispreferred) interpretation and the other was anomalous. However, it is possible that although the two conditions patterned together, their data patterns were generated by different processes. In the subset condition, it is possible that starting on Region 4, there was a cost to revising expectations toward a subset interpretation. The contrastive, singular indefinite condition was the unacceptable condition, and the increased reading times and proportion of regressions with respect to the bare plural contrastive condition could have been caused by this unacceptability.

Finally, there exists a possibility that rather than interpreting the singular indefinite DPs as complete complements to *than*, readers expected the full DPs following *than* to be the subject of a comparative clause, such as (260).

(260) During the theft, more cell phones [than a laptop was connected to] were stolen from the IT department.

Intuitively, the interpretation of a singular indefinite as the subject of a comparative clause seems unlikely. However, the observed interactions between the experimental factors and Trial Sequence could lend support to this interpretation. In Section 5.6, I will discuss a stronger cue toward the subset comparative interpretation, the word *just*, that eliminates the ambiguity introduced by a full-DP complement to *than*, and in Section 5.7 I will present an experiment that investigates eye movements in comparatives with and without this strong cue.

5.6 The Role of *Just* in Subset Comparatives

As shown in Section 5.2, many attested examples of subset comparatives include *just* in the complement of *than*.[6] *Just* occurs with both bare plural and full-DP complments to *than*. This is shown in example (261a). With contrastive comparatives, *just* is not licensed in the corresponding position. Unless *eagle* refers to a type of airplane, either form of (261) is unacceptable.

(261) a. More birds than just eagles/an eagle flew over the conservation area.

b. #More airplanes than just eagles/an eagle flew over the conservation area.

[6]Other elements can also be used in place of *just*, e.g., *merely* or *simply*, but I will continue to use *just* as a representative of this class of items.

From (261), we can tell that the presence of *just* in examples like these forces a subset interpretation. A pilot questionnaire, reported in detail in Grant (to appear), showed that the presence of *just* also improves acceptability of subset comparatives with full-DP complements to *than*. A sample item set from the pilot experiment is shown in (262), with mean acceptability ratings on a scale from 1 to 5 for each condition shown in parentheses. Conditions where a subset interpretation was licensed by the nouns used (262a-b) were rated as more acceptable than those without a viable subset comparative interpretation (262c-d). This effect was expected, as contrastive comparatives are not predicted to be acceptable with singular indefinite complements to *than*. For comparatives with a subset interpretation, the presence of *just* improved acceptability by 0.43 points, while there was an improvement of only 0.06 points for contrastive comparatives. The interaction between the presence of a subset comparative and the presence of *just* was significant, showing that the presence of *just* improves acceptability mainly for subset comparatives.

(262) a. More birds than an eagle were found in the conservation area. (2.34)

b. More birds than a feather were found in the conservation area. (2.01)

c. More birds than just an eagle were found in the conservation area. (2.77)

d. More birds than just a feather were found in the conservation area. (2.07)

The empirical facts that *just* is often found in subset comparative examples (and might be required in German and Dutch), that *just* improves the acceptability of subset comparatives, and that the presence of *just* can force a subset comparative interpretation, are clear. However, the question remains as to how *just* should be modeled in the syntax and semantics, or even the pragmatics, of subset comparatives. Is the presence of *just* or similar elements merely a reflection of the subset comparative interpretation, or does *just* contribute a part of the subset comparative interpretation?

In Section 5.4, I described a presupposition that characterizes subset comparatives, namely that the property of comparison is true of the complement to *than*. Here I will explore the idea that the Subset Comparative Presupposition is related to the meaning of *just*. Although the meaning associated with *just* and similar exceptives seems to fit with the presence of the SCP, this section will conclude that applying a causal link between the meaning of *just* and the SCP is ultimately a bit unsatisfying for reasons of structure.

How would *just* contribute this meaning to the computational semantics of subset comparatives? Although *just* has many uses in language (see Lee, 1987 for an interesting survey of uses in doctor-patient conversation), we can think of *just* as having a meaning something like *only* or *even*. *Even* and *only* are focus-sensitive operators that have been proposed to have both asserted meaning and presuppositional meaning (Horn, 1969). However, the two have been proposed to be different in terms of what is presupposed and what is asserted. Examples of the meanings of *only* and *even*, modified from (Rooth, 1985, following Horn, 1969 and Karttunen and Peters, 1979), are shown in (263) and (264). Subscript *F* marks semantic focus (as well as prosodic prominence).

(263) Only John$_F$ came to the party.

Assertion: No one who is not John came to the party.

Presupposition: John came to the party.

(264) Even John$_F$ came to the party.

Assertion: John came to the party.

Presupposition:

(i) Someone who is not John came the party.

(ii) For all x under consideration besides John, the likelihood of x coming is greater or equal to the likelihood of John coming to the party.

In terms of focus alternatives (Rooth, 1985), the asserted content of *only* in (263) excludes the possibility that any focus alternatives to *John* came to the party (e.g., not Jim, Sarah, etc.). Intuitively, *just* has a similar meaning to *only*, in the sense that it excludes members other members of the set of focus alternatives. For example (265) communicates that no one other than John came to the party.

(265) Just John$_F$ came to the party.

While there may be instances where *just* has exactly the meaning of *only*, it seems to carry an implicature about a scale of expectedness that is the reverse of the one carried by *even*. In (264), we get the meaning that John was less expected at the party (or possibly the most desirable as a party guest). In (265), the meaning is rather that John is the most expected (or possibly least desirable) party guest, and that no one less expected came to the party.

What part of the meaning of *just* is asserted and what is presupposed? The evidence that Horn presents that (263ii) is part of the presuppositional meaning of the sentence including *only* is first that negating a sentence with *only* does not negate this part of the meaning. Example (267) equally conveys the meaning that Muriel voted for Hubert, despite the negation.

(266) Horn (1969):4

Only Muriel$_F$ voted for Hubert.

(267) It's not true that only Muriel voted for Hubert.

Similarly, questions with *only* do not question the presupposed material. The question (268) can be felicitously answered with (268a), which states that another voter also voted for Hubert, but not with (268b), which denies the presupposed material.

(268) Horn (1969): 8-9

Did only Muriel vote for Hubert?

a. No, Lyndon did too.

b. *No, she didn't.

These tests applied to *even* support the split shown in (264), that what is presupposed with *only* is asserted with *even*. Negation seems to target the proposition that Muriel voted for Hubert in (270), and it is felicitous to answer (271) with (271b).

(269) Even Muriel voted for Hubert.

(270) It's not true that even Muriel voted for Hubert.

(271) Did even Muriel vote for Hubert?

a. *No, John did too.

b. No, she didn't.

Just seems to pattern more with *only* than *even* in terms of its asserted and presupposed meaning. Sentence (272) indicates that someone other than John voted for Hubert (perhaps someone who was less likely than John to do so), rather than indicating that John didn't vote for Hubert. Similarly the question (273) is felicitously answered with (273a) but not (273b).

(272) It's not true that just John voted for Hubert.

(273) Did just John vote for Hubert?

a. No, Mary did too.

b. *No he didn't.

As a result of the behaviour of *just* in contexts of negation and questions, I will assume that the split between assertion and presuppositional meaning for examples like (274) is the same as *only*, with the additional presupposition shown in (ii) which is in some ways the reverse of the corresponding part of *even*.

(274) Just John came to the party.

Assertion: No one who is not John came to the party.

Presupposition:

(i) John came to the party.

(ii) For some x under consideration besides John, the likelihood of x coming is lesser than the likelihood of John coming to the party.

A recent investigation into exceptives like 5.6 by Coppock and Beaver (Coppock and Beaver, 2012a,b) follows Beaver and Clark (2008) in assigning both the asserted and presupposed meaning of *only* and *mere* a scalar analysis. Under this view, the asserted meaning for (274) is that nothing *stronger* than the element modified by the focus-sensitive operator is true, while the presupposed content is that nothing *weaker* is true.

The Subset Comparative Presupposition does seem to act like the presupposed meaning of *just* statements. With respect to Horn's tests, negation does not seem to be able to target the SCP (275), and it is not felicitous to answer a question like (276) by referring to the presupposed material.

(275) It's not true that more birds than just an eagle flew over the conservation area.

(276) Did more birds than just an eagle fly over the conservation area?

No, it was just the eagle.

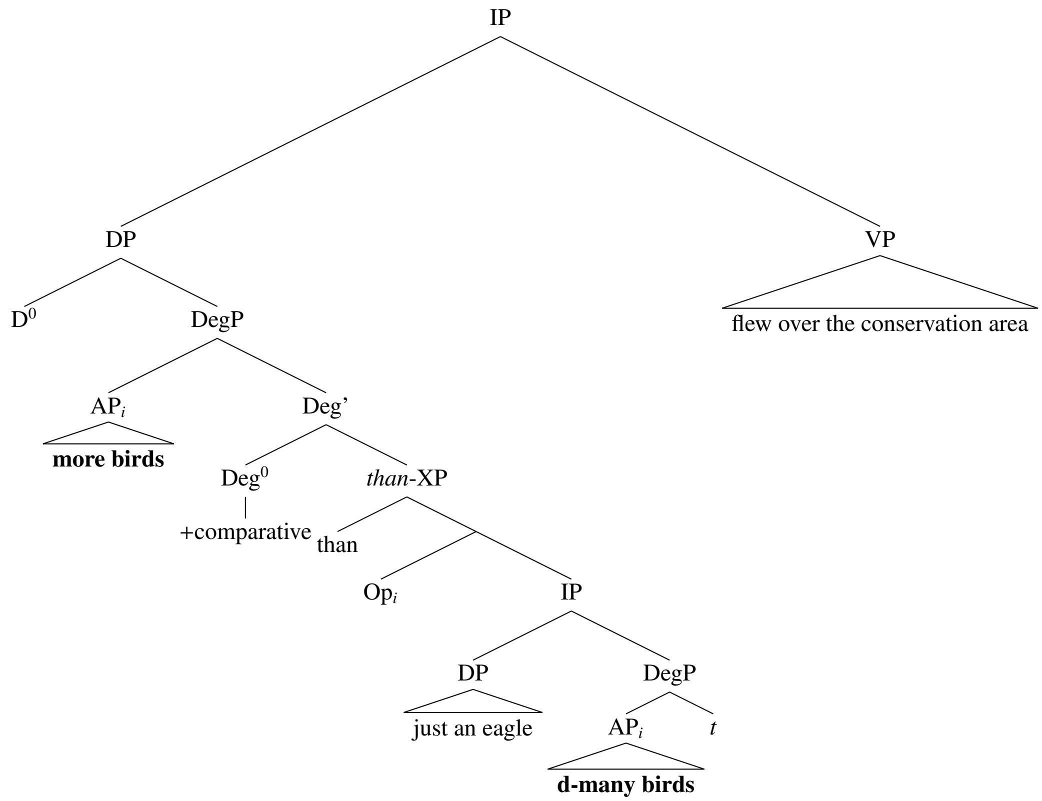
#No, there were no eagles.

Giving *just* a meaning like that of *only* seems to predict the correct meaning for subset comparatives. If the meaning of *just* introduces the presupposition that is inherent to all subset comparatives, then we are left with explaining how subset comparative interpretations can occur with *just* absent. One possibility is that in subset comparatives, there is *always* an element of meaning like *just*, but that this element can either be spoken as *just* or can be covert.

However, letting *just* do the work of introducing the SCP poses a problem for the structure of subset comparatives proposed in Section 5.3. The meaning we want in the presuppositional content of (277) is the proposition *an eagle flew over the conservation area*. However, this proposition can't be formed given either the Attributive NP-comparative or DP-internal subcomparative structures presented. The Attributive NP-comparative structure for (277) would be as in (278).

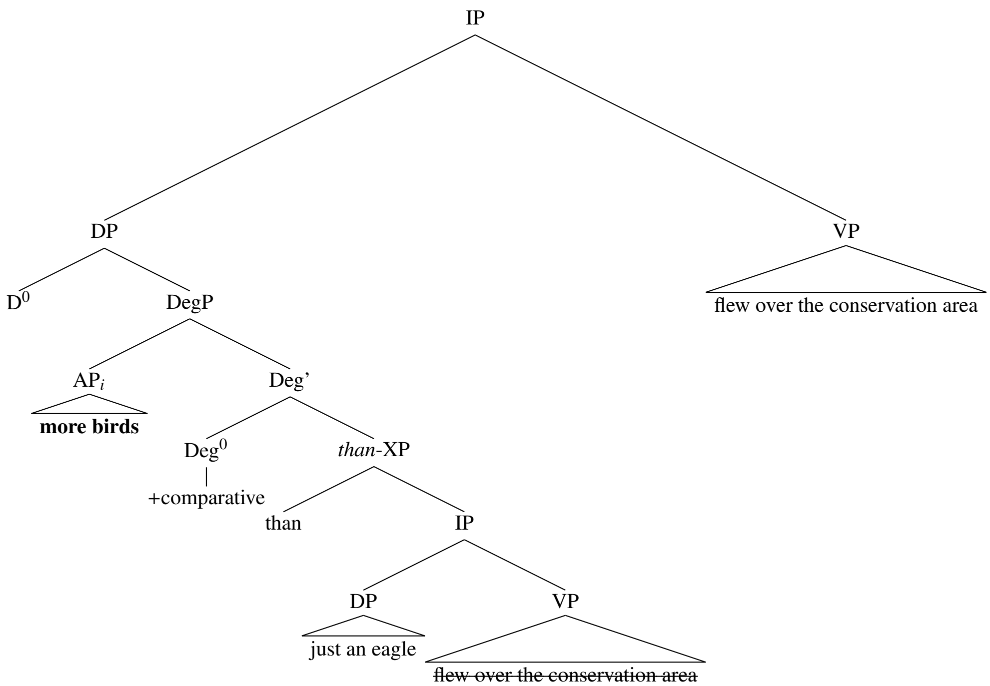
(277) More birds than just an eagle flew over the conservation area.

(278)



The architecture of (278) does not have a constituent containing *just an eagle flew over the conservation area*. Therefore, the meaning that one would have to give to *just* to trigger the SCP under this architecture would have to be complex and possibly specific to subset comparatives. A conclusion that could be drawn from this is that the architecture shown in (278) is not the right structure for subset comparatives, and that the complement to *than* in subset comparatives contains the same material as the main VP, but this material is deleted from the spoken form. Such a structure could look like (279).

(279)



The structure in (279) contains a constituent (minus *just*) corresponding to the material that we want to be in the presuppositional content of the sentence. However, this structure loses the natural consequence of requiring the subset relationship that was gained by using the Attributive NP-comparative structure. The two critical parts of the meaning of a subset comparative, the subset requirement and the SCP, cannot both follow directly from the structure of the sentence. How do we solve this conflict?

In principle, the conflict could be resolved by shifting one aspect of the subset comparative meaning from the compositional semantics or pragmatics of the sentence. Allowing the SCP to follow despite the lack of the appropriate semantics is undesirable, as shown above. Separating the subset relationship from the structure of subset comparatives is also an undesirable option for two reasons. First, the full DP syntactic form of the complement to *than* is only licensed when a subset relationship is present. Second, the presence of *just* is not licensed unless a subset relationship is present. These two requirements are shown in (280).

(280) # More cell phones than (just) a laptop were stolen.

In Section 5.9 I will introduce an account that has the potential to do a better job of predicting subset comparative behaviour than the structure in (278) plus *just*, thereby resolving the conflict between the subset requirement and the SCP. This account will allow the same architecture for contrastive and subset comparatives but will allow the arguments of *more (than)* to vary in their semantic type. The meaning of *just* would therefore be reflective of a subset interpretation, but not critical in calculating its meaning.

Even if *just* does not contribute the subset comparative meaning, the fact that its presence is a signal that a subset comparative interpretation is required may have an effect on the processing of subset comparatives. In the next section, I will present an experimental test of the effect of *just* on subset comparative processing.

5.7 The Role of *Just* in Processing Subset Comparatives

While the presence of a singular indefinite DP following *than* did not unequivocally disambiguate toward a subset interpretation, the presence of *just* is a more overt indicator that a subset interpretation is present. Examples like (232) show that, in fact, overt *just* actually *forces* a subset interpretation. Therefore, in order to further test the Contrast Preference Hypothesis and to find out whether *just* facilitates processing of subset comparatives in addition to improving acceptability, a second study of eye movements during reading was carried out.

5.7.1 Experiment 8

Experiment 8 was conducted in order to test the effect the presence of *just*, a strong cue toward a subset interpretation, on the time course of processing subset comparatives. Subset comparatives with *just* provide a case of subset comparatives that are both impossible to mistake for contrastive comparatives and do not have a temporary ambiguity between a subset comparative and a clausal comparative structure, as was the case with the full-DP complements to *than* in Experiment 7. Because of the strong cue that *just* provides, any increased processing difficulty for subset comparatives with *just* present as compared to contrastive comparatives (with *just* absent) can be interpreted as a processing cost associated with computing a subset comparative interpretation (including an immediate disconfirmation of the expectation for a contrastive comparative). In contrast, the increased reading times for subset comparatives without *just* in Experiment 7 were interpreted as a cost associated with revising toward a subset interpretation from a default contrastive comparative interpretation that had been erroneously maintained for several words past the critical comparative region. This difference in the underlying cause of the processing difficulty gives rise to a prediction for the time course of processing subset comparatives with and without *just*. With *just* present, we would expect the processing cost to be immediate, for example on the complement to *than*, while the processing difficulty for subset comparatives without *just* would appear downstream of the critical region. The latter half of this prediction was borne out in Experiment 7. Experiment 8 included subset comparatives (and contrastive comparatives) with and without *just* to examine the time course of processing subset comparatives that are or are not morphologically signaled.

5.7.1.1 Methods

5.7.1.1.1 Materials Twenty-four item sets like the one in 281 were constructed (see Appendix A for a list of experimental items) and counterbalanced across four lists. The regions of analysis that will be discussed in the results section are numbered and delimited by |. Like Experiment 7, Experiment 8 manipulated the Type of comparative between subset and contrastive, and the presence or absence of *just*. In Experiment 8, all complements to *than* were bare plurals. However, condition (281d) was still odd or unacceptable because of the use of *just* with a contrastive item. The sentence frames were modified from Experiment 1 to ensure that the the subset relationships and contrastive relationships between the associates of comparison and complements to *than* would be identical across the two experiments.

(281) a. In the book, it says that$_{1}$| more insects$_{2}$| than$_{3}$| butterflies$_{5}$| are commonly$_{6}$| found$_{7}$| near ponds.$_{8}$|

b. In the book, it says that$_{1}$| more mosquitoes$_{2}$| than$_{3}$| butterflies$_{5}$| are commonly$_{6}$| found$_{7}$| near ponds.$_{8}$|

c. In the book, it says that$_{1}$| more insects$_{2}$| than$_{3}$| just$_{4}$| butterflies$_{5}$| are commonly$_{6}$| found$_{7}$| near ponds.$_{8}$|

d. #In the book, it says that$_{1}$| more mosquitoes$_{2}$| than$_{3}$| just$_{4}$| butterflies$_{5}$| are commonly$_{6}$| found$_{7}$| near ponds.$_{8}$|

5.7.1.1.2 Procedure Twenty-four UMass undergraduates participated for course credit in psychology. The experimental procedure was the same as in Experiment 7.

The experimental items were randomized and intermixed with 96 sentences from unrelated experiments. On approximately one quarter of trials, subjects were presented with a comprehension question following the experimental sentence.

5.7.1.2 Results

Prior to statistical analysis, 14% of trials were removed due to track losses. The criteria for minimum and maximum fixation times were identical to those used for Experiment 7. Overall question comprehension accuracy was 92%.

	Subset		No Subset	
	Just Absent	*Just* Present	*Just* Absent	*Just* Present
First Pass Time (ms)				
Region 1	350	368	348	370
Region 2	389	376	383	408
Region 3	234	239	241	227
Region 4	NA	244	NA	221
Region 5	270	274	252	251
Region 6	305	283	314	315
Region 7	270	265	289	267
Region 8	513	446	524	470
Go-Past Time (ms)				
Region 1	350	368	348	370
Region 2	431	409	458	535
Region 3	275	270	276	304
Region 4	NA	299	NA	274
Region 5	395	324	291	308
Region 6	363	292	344	357
Region 7	321	314	342	323
Region 8	715	701	748	748
% Regressions Out				
Region 1	NA	NA	NA	NA
Region 2	7.4	7.1	10.8	15.8
Region 3	3.5	3.5	3.2	4.2
Region 4	NA	16.0	NA	15.7
Region 5	27.9	11.5	13.6	15.9
Region 6	10.2	1.7	5.2	5.5
Region 7	8.3	13.1	13.7	15.6
Region 8	24.0	28.8	24.8	25.2

Table 5.2. Means for eye-movement measures, Experiment 8

5.7.1.2.1 First Pass Time In First Pass Time, there were no significant effects of experimental factors. On Region 5, the complement to *than*, subset conditions had numerically longer First-Pass Times than contrastive conditions, but this effect did not reach significance.

5.7.1.2.2 Go-Past Time Figure 5.7 shows the pattern of Go-Past Times by region in Experiment 8. In Go-Past Time, there was an unexpected interaction between Type and Just such that the contrast, *just*-present condition had the longest Go-Past Time overall (Estimate = 111.06, SE = 52.06, t = 2.134). This effect was accompanied by an effect of Type, such that contrastive conditions had longer Go-Past Times than subset conditions (Estimate = -66.937, SE = 30.71, t = -2.179). At this point in the experimental sentences, the only difference between conditions was between the subset and contrastive conditions, which had different plural NPs as the associate of comparison. Therefore, the interaction is likely to be spurious. There were no significant effects on Regions 3 or 4. On Region 5, the complement to *than*, there was a significant effect of Type such that subset comparatives had longer Go-Past Times than contrastive conditions (Estimate = 64.09, SE = 26.45, t = 2.423). Numerically there appears to be an interaction such that the subset, bare plural condition had the longest overall Go-Past Times, but this interaction did not reach significance (Estimate = 87.62, SE = 58.16, t = 1.506). The subsequent region, Region 6, did not show any significant effects initially, but visual inspection of the data revealed an interaction between Trial Sequence and the presence of Just. When interactions between Trial Sequence and the other factors were included in the model, the interaction between Just and Trial Sequence was significant (7.518, SE =2.378, t = 3.161). This interaction appears to be driven by an increase in Go-Past Time for the *just*-absent, subset condition, whereas numerically subset comparatives with *just* had shorter Go-Past Times over the course of the Experiment. While the effect of Trial Sequence was included in the model as a continuous factor, Figure 5.8 shows the effect of Trial Sequence by presenting the means for the experimental conditions in the first and second half of the trials. There were no significant effects of experimental predictors on the final two regions of the sentence, Regions 7 and 8.

5.7.1.2.3 Regressions Out The pattern of Regressions Out by region is shown in Figure 5.9. On Region 2, the same spurious effect found in Go-Past Time was again present. The contrast, *just*-present condition showed numerically the greatest proportion of Regressions out, followed by the contrast, bare condition and then the subset condition. While the marginally significant effect of

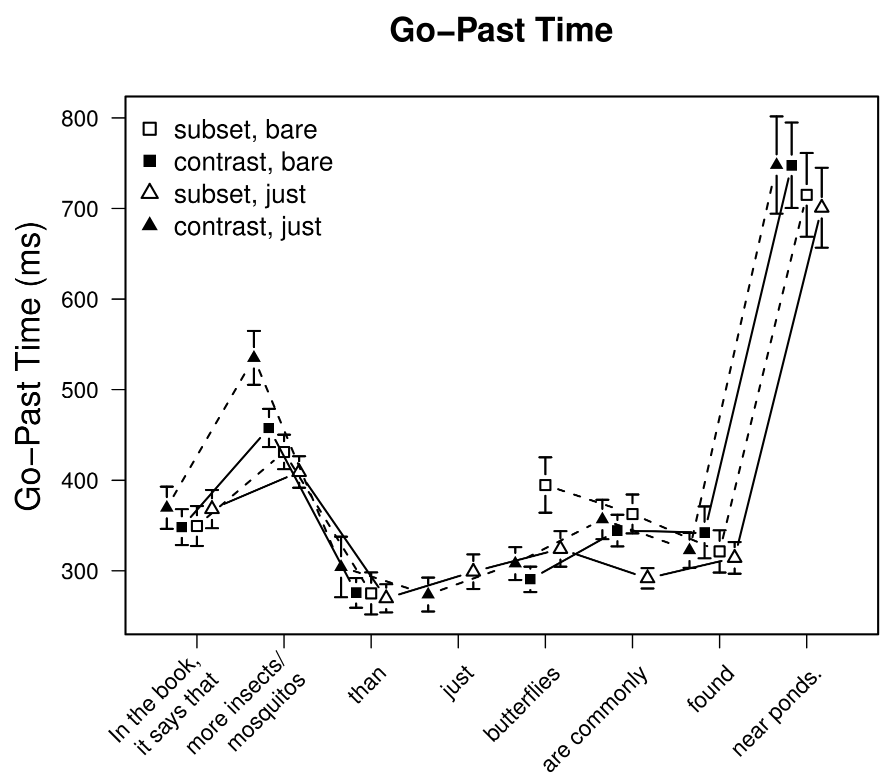


Figure 5.7. Mean Go-Past Times by region, Experiment 8.

Type (Estimate = -.79, SE = .429, z = -1.844, p = .065) is predicted on this region due to a difference in lexical items, there was also a marginal effect of Just that was not predicted (Estimate = -.644, SE = .386, z = -1.668, p = .095). There were no other significant effects of the experimental predictors until Region 5, the complement to *than*, where there was a significant interaction of Type and Just (Estimate = 1.645, SE = 0.698, z = 2.359, p = .018). On Region 5, the subset, bare plural condition had the most regressive eye movements of all conditions, and therefore more than the subset, *just*-present condition. The reverse was numerically true for the contrastive conditions, where there were numerically more regressions in the *just* -present condition than the *just*-absent condition. In addition to the interaction, there was also a marginal overall effect of *just* (Estimate = 0.662, Se = 0.020, z = 1.885, p = .0594), but this effect is likely due to the large proportion of regressions out of the bare, subset condition. The subsequent region, Region 6, showed a similar interactive pattern to

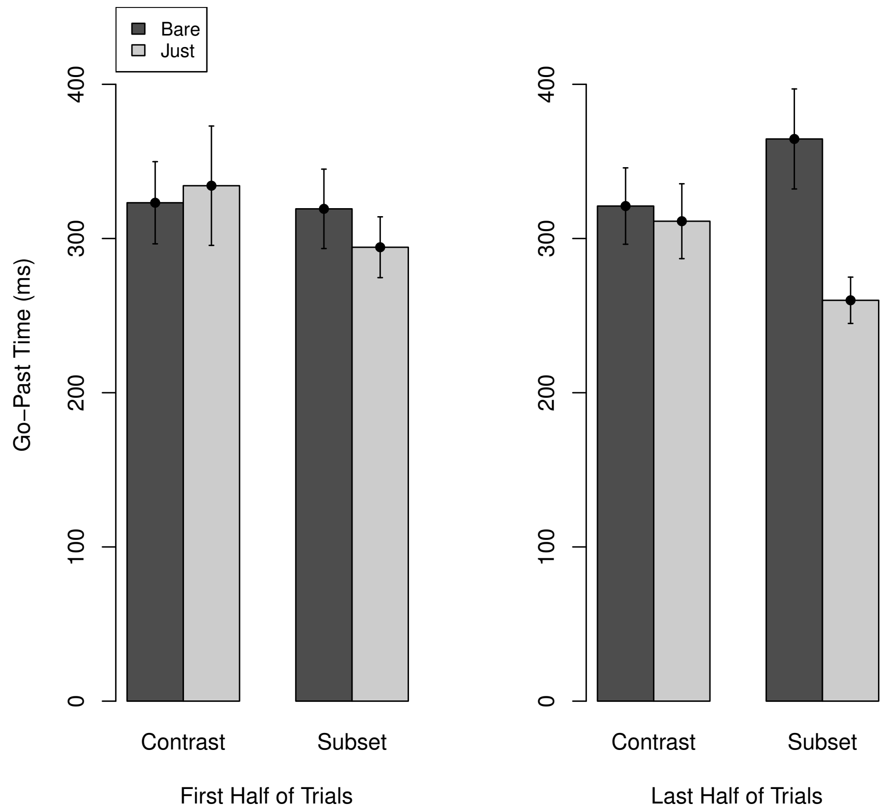


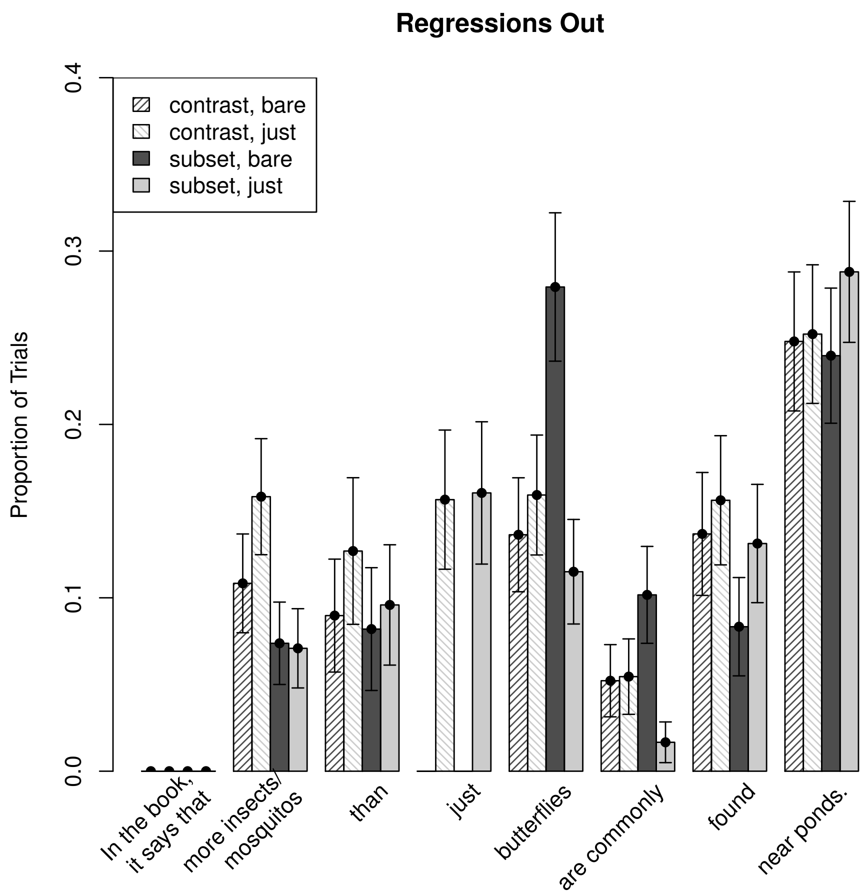
Figure 5.8. Go-Past Times for the first and second halves of experimental trials, Experiment 8.

Region 5, although the interaction on Region 6 was only marginally significant (Estimate = 2.119, SE = 1.150, z = 1.843, p = .0653). No experimental factors were significant for Regions 7 and 8.

5.7.1.3 Discussion

The results of Experiment 8 show that the presence of *just* has a very different effect on the processing of subset comparatives than the full-DP complement to *than* did in Experiment 7. The fact that the subset, *just*-present condition had the numerically fewest regressions out of Regions 4 and 5 shows that the presence of *just* facilitates the processing of subset comparatives. In addition, I will argue, the presence of *just* in the experimental items changed the timecourse of processing subset comparatives across the board, even those with *just* absent.

In Regressions Out (and the similar, though nonsignificant pattern in Go-Past Time) on the complement to *than* and the subsequent region, there was a significant interaction between Type



[h!]

Figure 5.9. Mean Go-Past Times by region, Experiment 8

(contrastive vs. subset) and the presence of absence of *just*. On these regions, the subset, bare plural condition had the most regressions. Recall that in Experiment 7, this condition showed the greatest number of regressions only on the final region. I proposed that this effect arose because recognition of the subset comparative interpretation was delayed when there was no overt signal that such an interpretation was present. Contrary to the previous result, in the current experiment the subset, bare plural condition immediately showed an increase in regressions over the other conditions. Why was the effect apparent earlier in Experiment 8 than Experiment 7? One explanation is that the presence of subset comparatives with *just* in the experiment alerted readers to the possibility of a subset interpretation, and drew their attention to the relationship between the complement to *than* and the associate of comparison on all of the experimental trials.

Experiment 7 showed interesting interactions for some measures and regions between Experimental manipulations and Trial Sequence. In Experiment 8, there was an interaction in Go-Past Time for Region 6 between Trial Sequence and the presence of *just*. The *just*-present conditions showed an overall decrease in Go-Past Time over the course of the experiment, while bare conditions overall showed an increase. As shown in Figure 5.8, the effect appears to be largely driven by the subset conditions. The interaction between Trial Sequence and the presence or absence of Just is consistent with the idea that the early penalty for the bare plural, subset condition in Experiment 8 as compared to Experiment 7 is due to the presence of overtly signaled (by *just*) subset comparatives in the experiment. Over the course of the experiment, subset comparatives that did not include *just* elicited more processing difficulty, while subset comparatives with *just* became easier to process. The lack of a three-way interaction with Just, Type and Trial sequence suggests that perhaps the presence of *just* may be associated with shorter Go-Past Times in Region 6 for both contrastive and subset comparatives. One could imagine that the presence of *just* would focus the reader's attention on the relationship between the associate of comparison and the upcoming NP, allowing the reader to easily dismiss the sentence as anomalous if the subset relationship did not hold.

Taken together, the results of Experiments 7 and 8 show that readers default toward a contrastive comparative interpretation. Subset comparatives showed a cost in processing difficulty in both experiments when the subset interpretation was not unambiguously signaled by *just*. However, the difference in the time course of the subset comparative difficulty showed that the presence of overtly signaled subset comparatives in the same experimental context could prime readers to recognize and process the subset relationship immediately.

The previous sections have discussed subset comparatives that must be interpreted as such, due either to the lexical/conceptual relationship between the sets in the comparative or due to the presence of disambiguating material such as *just*. The next section will discuss a case of comparatives that are ambiguous between a contrastive and subset interpretation, which will provide both an additional empirical testing ground for the Contrast Preference Hypothesis and an additional source of evidence for the appropriate linguistic formalization of subset comparatives.

5.8 Subset comparative clauses

Up to now, the subset comparatives discussed have gained their interpretation either through a lexical/conceptual relationship between two nouns (e.g., *eagle - bird*, *Jennifer Aniston - actress*), or they have included *just*, which forces a subset relationship. For example, in (232), repeated in (282), empty seats must be interpreted as a problem posed by Yankee stadium because *just* is not licensed in a typical contrastive comparative. For (282) and the other examples discussed above, the subset interpretation is the only viable one. However, a small modification (removing *just* and changing the main clause verb) of (282) shows that there can be cases that are ambiguous between a contrastive and a subset interpretation. In (283), one could get a similar subset interpretation to (282, but the evidence collected so far would suggest a preference for a contrastive interpretation in which the number of problems that Yankee Stadium has is greater than the number of empty seats that Yankee stadium has.

(282) Yankee stadium poses **more problems than just empty seats**.
(Brenden Monroe, www.bleacherreport.com, 23 April 2009)

(283) Yankee stadium has more problems than empty seats.

In this section, I will suggest that comparatives that are ambiguous between contrastive and subset interpretations are not limited to those with bare plural NP complements to *than*. To illustrate, consider example (284). Intuitions suggest that this example has two possible meanings. The first, the contrastive or typical comparative meaning, is that the number of crimes that Linda reported is greater than the number of crimes that she directly witnessed. Under this interpretation, paraphrased in (284a), the sentence would be true if for example Linda reported five crimes that she heard about second-hand, but failed to report any of the three crimes she saw happen. The second meaning, the subset interpretation (paraphrased in 284b), would make the sentence true if Linda reported all of the crimes that she directly witnessed and one or more that she only knew about indirectly.

(284) Linda reported more crimes than she directly witnessed.

a. Linda reported a larger number of crimes than the number of crimes she directly witnessed (not necessarily the same ones).

b. Linda reported all of the crimes she directly witnessed, plus some others.

If the subset interpretation is available for sentences like (284), it would mean that subset comparatives are not limited to those with NP or DP complements to *than*. The distribution of *just*, for example, does not extend to comparative clauses, as shown in (285a). In order to use *just* in the way that improved the subset comparative examples earlier in the chapter, one would have to change the standard of comparison to a DP with a clausal modifier, as shown in (285b).

(285) a. *Linda reported more crimes than just she directly witnessed.

b. Linda reporter more crimes than (just) the ones she directly witnessed.

From a processing perspective, subset clauses like (284) are interesting because they cannot be overtly signaled as subset comparatives without changing the comparative clause to a DP like (285b). If there is an initial preference for contrastive comparatives, it must be the discourse coherence or plausible compatibility between the associate of comparison and the comparative clause that would trigger revision toward a subset interpretation.

Before discussing the implications of subset comparative clauses for the theory of the syntax and semantics of comparatives and the predictions for the processing of comparatives, it must first be established whether naive readers actually do get a subset interpretation of sentences like (284), and if so what factors make this interpretation more likely. In the next section, I will present the results of a pilot study that tests for the presence of a subset clause interpretation, and also tests whether the compatability of the predicates in comparatives affects the likelihood of a subset interpretation.

5.8.1 Pilot Experiment 9

In order to determine whether readers ever get the subset interpretation of comparative clauses without *just*, a small pilot study was conducted using ratings and forced-choice between two alternative paraphrases for the meaning of sentences like (286). The working hypothesis is that sentences like (286), repeated from (284), have two possible interpretations: the typical comparative interpretation that asserts an ordering between two quantities, not necessarily overlapping, and the subset interpretation.

(286) Linda reported more crimes than she directly witnessed.

5.8.1.0.1 Materials This experiment tested subjects' interpretations of sentences like (286). As a comparison to the putatively ambiguous (286), the experiment included a condition in which the standard of comparison was a DP modified by a relative clause, shown in (287). This condition was meant to disambiguate toward the subset interpretation by the use of *the ones*, which refers back to the same crimes in the *more-NP*.

(287) Linda reported more crimes than the ones she directly witnessed.

The final experimental manipulation was meant to assess whether discourse conditions could influence the interpretation of comparatives. While a subset interpretation is quite plausible for (286), due to the presumably high likelihood of a person reporting a crime that she had directly witnessed, the example (288) contains predicates that make a subset interpretation less felicitous.

(288) Linda committed more crimes than she directly witnessed.

The design of the experiment fully crossed the two factors (the Syntax of the standard of comparison and the Felicity of the subset interpretation) such that the last condition included sentences with *the ones* and an infelicitous discourse, such that this condition was predicted to be quite odd. A full item set is shown in (289), with this last condition in (289b). Sixteen of these item sets were constructed for the experiment and counterbalanced across four experimental lists. All items are included in Appendix A.

(289) Full design, pilot experiment 9

a. Linda reported more crimes than she directly witnessed.

b. Linda reported more crimes than the ones she directly witnessed.

c. Linda committed more crimes than she directly witnessed.

d. # Linda committed more crimes than the ones she directly witnessed.

5.8.1.0.2 Procedure Twenty UMass undergraduate completed a paper-and-pencil questionnaire for extra credit in introductory linguistics courses. Subjects read the sentence, and were then asked to both rate the sentence on a scale from 1 (completely unacceptable) to 7 (completely acceptable) and to choose a paraphrase from two choices. One choice corresponded to the subset interpretation (e.g., *Linda {reported/committed} all of the crimes that she directly witnessed, plus some others*) and a typical comparative interpretation (e.g., *Linda {reported/committed} a larger number of crimes than the number she committed (not necessarily the same ones)*). The items from this experiment were interspersed with items from other experiments, for a total of 48 items.

5.8.1.0.3 Results The mean ratings and paraphrase choices are shown in Table 5.3. One item was removed from analysis due to a coding error. There were no significant differences between the mean ratings of each condition, although there was a numerical trend toward higher ratings for the subset-felicitous items overall (Estimate = 0.30, SE = 0.21, t = 1.440). For the paraphrase choices, subset-felicitous items were more likely to receive a subset interpretation (Estimate = 1.91, SE = 0.47, z = 4.083, p < .001). There was a marginal trend toward an interaction such that there was an increase in subset paraphrase choices for felicitous sentences with *the ones* over felicitous typical comparatives, while there was no such difference for the subset-infelicitous sentences (Estimate = -1.14, SE = 0.68, z = -1.68, p = 0.093). When the two Felicity conditions were compared for the typical comparative clauses only, the difference remained significant (Estimate = 1.22, SE = 0.50, z = 2.43, p = 0.015).

		Subset-Felicitous	Subset-Infelicitous
Rating			
	Comp. clause	5.88	5.57
	The ones	5.82	5.42
Proportion Subset			
	Comp. clause	.33	.12
	The ones	.49	.11

Table 5.3. Mean ratings and paraphrase responses, Experiment 9.

5.8.1.0.4 Discussion The results of Experiment 9 how that the subset interpretation is available for comparative clauses when the discourse conditions are felicitous, as shown by the difference in subset paraphrase choices between the subset-infelicitous and the subset-felicitous conditions. However, the subset paraphrase was still chosen only on a substantial minority (approximately one-third) of the trials. Still, the results of the experiment show that comparative clauses can be ambiguous between a subset comparative and a typical comparative interpretation, which has implications for our understanding of subset comparatives and for comparative interpretation in general.

A secondary and somewhat surprising result of the pilot study involved the interpretation of the conditions where the standard of comparison included *the ones*. This structure for the standard of comparison was thought to disambiguate toward a subset interpretation, but these items received a subset interpretation only approximately half of the time when the discourse conditions were felicitous, and only 11% of the time when the subset interpretation was infelicitous. There are at least three possible explanations for this result. First, it is possible that the language of the paraphrases may have biased subjects toward the typical comparative paraphrase. Such a bias cannot be attributed to length of the paraphrase, however, because the subset paraphrase was the shorter one in each case. Second, it could be the case that subjects prioritized the use of discourse information above syntactic information in making their paraphrase choices. However, this would not have predicted the lower than expected rate of subset choices in the subset-felicitous condition. Finally, it is possible that *the ones* simply does not disambiguate between readings for the subjects who participated. If this is the case, then our theory of the syntax and semantics of these examples would have to be significantly revised.

5.8.2 Implications for a theory of comparative interpretation

The availability of a subset interpretation for comparative clauses calls into question an account that relies on *just* , either overt or covert, to introduce the subset comparative presupposition. As mentioned in earlier in this section, sentences like (284) are infelicitous with *just* even under a subset interpretation. Even if *just* is moved to modify the predicate of the comparative clause, the sentence does not gain a subset reading. Sentence (290b), for example, is not forced to have a subset interpretation by the presence of *just* (it does, however, have a well-formed interpretation in which *just* is interpreted in its temporal sense).

(290) a. Linda reported more crimes than (*just) she directly witnessed.

b. Linda reported more crimes than she just directly witnessed.

To get the subset comparative meaning, it seems that comparative clauses can be interpreted as sets, equivalent to the DP conditions from the pilot experiment discussed above (shown in (291), wherein the *than*-constituent has a meaning like (292).

(291) Linda reported more crimes than (just) the ones she directly witnessed.

(292) Linda reported more crimes than $\{\iota x.x\ is\ a\ crime\ \&\ Linda\ directly\ witnessed\ x\}$

Because the meaning of (284) is equivalent to (291), which better conforms to the subset comparatives discussed in earlier sections, we then want to know how subset comparative clauses get to that meaning. Is it a matter of coercion from a typical comparative interpretation in which the comparative clause is interpreted as a degree, as in (293), to a representation like (292)? Or, are comparative clauses ambiguous between degree and set semantics?

(293) Linda reported more crimes than $\lambda\, d.Linda\ directly\ witnessed\ d - many\ crimes$

Future research is required to determine between these two possible accounts. For example, one could test to see whether the processing patterns of subset comparative clauses show evidence of coercion, as has been found by studies of coercion of other types (Brennan and Pylkkänen, 2008).

One commonality between clausal subset comparatives and other subset comparatives is that they seem to be impossible with comparisons other than cardinalities. For example, neither (294) nor (295) has a subset interpretation, according to my own intuitions. Either sentence could be true if the main clause predicate is not true of the complement to *than*: eagles need not have flown over the conservation area in (294), and the crimes directly witnessed need not be reported by Linda in (295).

(294) Larger birds than eagles flew over the conservation area.

(295) Linda reported crueller crimes than she directly witnessed.

5.9 Subset comparatives as true subsets

In Section 5.3, I showed two possible structures for subset comparatives. These included DP-internal subcomparatives and also Attributive NP-comparatives. Maintaining these analyses for subset comparatives has two major problems. First, as pointed out in Section 5.6, the constituent required to generate the Subset Comparative Presupposition is not present in the representation built on the Attributive NP-comparative structure. Second, a subset comparative meaning can arise from *than*-clauses, which cannot be analyzed from the DP-internal subcomparative or Attributive NP-comparative structure without somehow coercing the clause into an NP/DP. One way that these problems can be reconciled is to change our view of comparatives to allow comparisons of sets themselves, rather than comparing only degrees or cardinalities generated from sets. In this section, I will sketch out this type of account and show that it solves some of the remaining problems of subset comparative structure and interpretation.

The semantic claim is that *more (than)* has two possible interpretations. Under one interpretation, comparatives compare sets of degrees (e.g., Heim, 2000). This account claims that *more* takes two arguments that are sets of degrees (or functions from degrees to properties, call these Q_1 and Q_2) (type $<< d, e.t >< d < et >>< et > t >$) and one set of individuals (or a property, call it P) to return a truth value. The semantics for this first *more* is shown in (296). Applied to an example like (297), this semantics gives rise to the interpretation that the degrees to which there are stolen laptops is a proper subset of the degrees to which there are stolen cell phones, as shown in (298), in the same way that, for example, 2 might be understood to be a proper subset of 3.

(296) $[[more_1]]] = \lambda Q_2 \lambda Q_1 \lambda P[\{d : Q_2(d) \cap P\} \subset \{d : Q_1(d) \cap P\}]$

(297) More cell phones than laptops got stolen.

(298) $\{d : d$-many x are laptops and got stolen$\} \subset \{d : d$-many x are cellphones and got stolen$\}$

The second interpretation for *more*, shown in (299), is the one that is deployed in subset comparatives. In this interpretation, it is not sets of degrees that are compared using the proper subset relationship, but sets of individuals. The denotation of $more_2$ is of type $<< et >< et >< et > t >$, or in other words Q_1 and Q_2 are sets of individuals rather than sets of degrees. Now let us apply this interpretation to the example in (297), which is contrastive and not a subset comparative. From the paraphrased semantics in (300), one can see that the interpretation is not felicitous given the world knowledge that laptops are not cellphones, and therefore it does not make sense for one set to be a proper subset of the other.

(299) [[*more*$_2$]] = $\lambda Q_2 \lambda Q_1 \lambda P[\{Q_2 \cap P\} \subset \{Q_1 \cap P\}]$

(300) #{x : x are laptops and got stolen} $\subset$ {x : x are cellphones and got stolen}

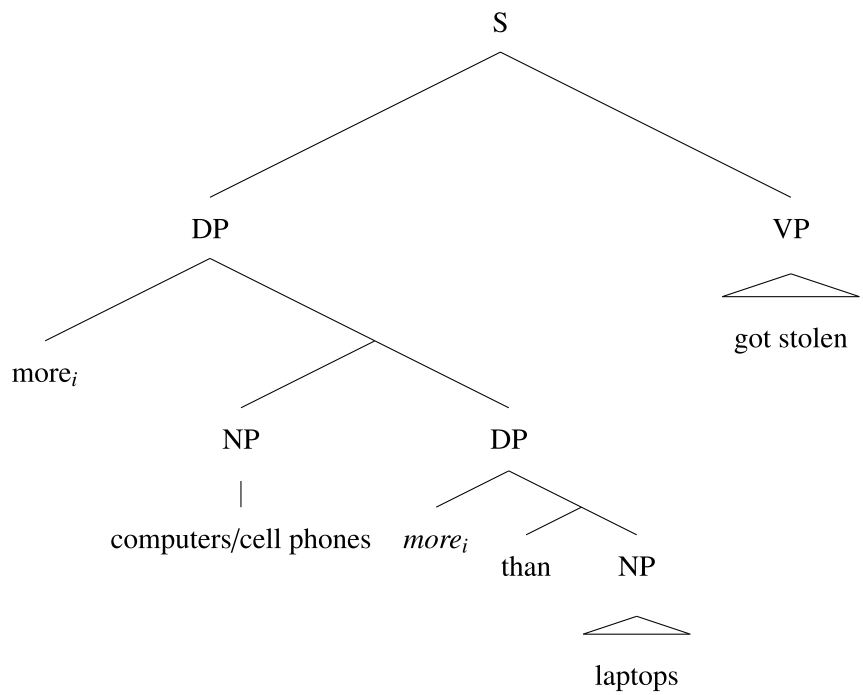
However, applied to a subset comparative like (301), *more*$_2$ gives rise to a semantic representation (302) that (mostly) captures the intuitive meaning of the example. This interpretation of *more* has a built-in requirement that a comparative of this kind will be infelicitous unless a proper subset relationship is plausible in the context.

(301) More computers than laptops got stolen.

(302) {x : x are laptops and got stolen} $\subset$ {x : x are computers and got stolen}

The difference in semantics between *more*$_1$ and *more*$_2$ shown in (296) and (299) nicely captures the difference between contrastive and subset comparative interpretations. However, the semantics is not straightforwardly compatible with the Attributive NP-comparative structure discussed in earlier sections. The meaning of *more* associated with the subset comparative, *more*$_2$, takes as its arguments two sets or properties, while the semantics of Attributive NP-comparatives requires that the complement of *than* is a degree. However, the semantics for *more*$_1$ and *more*$_2$ are compatible with the DP-internal subcomparative structure, as they are very similar to the Keenan (1987)-style semantics for *more (than)*. Both the contrastive (*more*$_1$) and subset (*more*$_2$) interpretations are possible given the structure in (303).

(303)



Adopting the structure in (303) for subset comparatives, however, loses one advantage of the Attributive NP-comparative structure, namely that what follows *than* in subset comparatives can be a full, and possibly singular, DP. In order for examples like (304) to have the DP-internal subcomparative structure, DPs like *my laptop* would have to be coerced into a property, as shown in (305).

(304) More computers than my laptop were stolen.

(305) $\{x : x$ is my laptop and got stolen$\} \subset \{x : x$ are computers and got stolen$\}$

Partee (1986) discusses the possibility of interpreting NPs as properties (type $< et >$). The proposal offered in that paper is that NPs can, in principle, be interpreted in three semantic types: type e, for individuals, type $<< et > t >$ for generalized quantifiers, and type $< et >$ for "predicative" NPs. One piece of evidence Partee cites for the predicative/property interpretation is that NPs can appear as complements to some verbs, e.g., *consider*, that select for properties. When NPs appear as complements to these verbs, they can also be conjoined complements with Adjective Phrases, which must be interpreted as type $< et >$, as shown in example (306).[7]

[7] As Partee notes, not every NP/DP can be interpreted as type $< et >$. In example (i), for instance, the DP *every authority on unicorns* is not allowed to conjoin with an Adjective Phrase as a complement to *consider*. While further

(306) Partee (1986): 3

Mary considers John competent in semantics and an authority on unicorns.

A remaining issue is that of the Subset Comparative Presupposition. Does this new semantics for subset comparatives do a better job than the Attributive NP-comparative semantics at predicting the presuppositional content of subset comparatives? Given the semantics of $more_2$, the Subset Comparative Presupposition can be re-stated as a presupposition that the set corresponding to Q_2 is non-empty.

(307) Subset Comparative Presupposition (Set version):

In subset comparatives, the intersection between the set picked out by Q_2 and the set picked out by P is non-empty.

Does (307) follow from the semantics defined for $more_2$? The answer to this question is that it does follow, but only in so far as it follows from the semantics for $more_1$. If *more* is encoded as a quantifier as it is in $more_1$/$more_2$, then we might expect it to act like other quantifiers. Strong quantifiers like *every* imply the non-emptiness of their restrictor. For example, even though (308) is true if there were no cell phones in the context, it carries an implicature that there were at least some cell phones (and those were stolen). Given that both $more_1$ and $more_2$ are quantificational, they might both have the same implicature. However, the two interpretations of *more* quantify over different semantic types. In (309), which would use $more_1$, the implicature would be that the set of degrees to which laptops were stolen is non-empty. If zero is a possible degree value on the scale of cardinalities, then the implicature could go through even if no laptops were stolen. For (310), having a non-empty restrictor would mean that the set of laptops that were stolen would be non-empty. From this, the implicature that at least one laptop was stolen would follow.

(308) Every cell phone was stolen.

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examination is required on the matter, upon initial inspection such DPs are also not licensed in subset comparatives, as shown in (ii).

i. *John considers the faculty competent in semantics and every authority on unicorns.

ii. *More birds than every eagle were found in the conservation area.

(309) More cellphones than laptops were stolen.

(310) More computers than laptops were stolen.

Tying the Subset Comparative Presupposition to the meaning of *more* rather than to the presence of *just* has another advantageous prediction over the Attributive NP-comparative account, which is that the subset comparative interpretation is unavailable for comparatives with other scalar adjectives. For example, a subset interpretation of (311) is not possible even if *just* is inserted (which just causes the sentence to be odd), which was shown above in (295) also for subset comparative clauses.

(311) Taller men than (*just) my father came to the party.

Another potential advantage of treating subset comparatives as true (proper) subsets is that this analysis could be applied to subset comparative clauses as well. In contrastive, typical interpretations, comparative clauses denote a set of degrees, as shown in (312). However, in the case of subset comparatives, we have seen that the complement to *than* is interpreted as a set of individuals. For a comparative clause, interpreting the complement to *than* as a set of individuals creates a meaning much like what a relative clause would have, as shown in (313-314).

(312) Contrastive:

Linda reported more crimes than λd. she directly witnessed $\underline{d\text{-many crimes}}$.

$\{d : d\text{-many x are crimes and Linda directly witnessed x}\} \subset \{d : d\text{-many x are crimes}\}$

(313) Subset:

Linda reported more crimes than λx. she directly witnessed $\underline{x}$

(314) Relative Clause:

Linda reported the crimes that λx. she directly witnessed $\underline{x}$

Although the 'true subset' analysis can be applied to subset comparative clauses, there is still some question as to whether this is the best analysis for these cases. One might argue that for comparative clauses, which for example cannot be disambiguated with *just*, there is no definitive way to tell whether the subset interpretation is encoded in the semantics of the example, or whether it arises from pragmatics only. One potential argument in favour of the analysis in (313) is that there are other *than*-clauses in English that appear to be interpreted as predicates of individuals as well. In examples with *other* or *different*, such as (315a), a good hypothesis for the interpretation of the *than*-clause would be that of (315b) (see Beck (2000) for more discussions of examples with *different*).

(315) a. Linda reported other/different crimes than she witnessed.

b. Linda reported other/different crimes that λx. she directly witnessed $\underline{x}$

A final question for the true subset analysis is how lexical/conceptual knowledge can rule out the degree or cardinality interpretation of *more*, $more_1$. In principle, the semantic types of the arguments should allow for either semantics of *more*, however a contrastive reading is never available for sets that are understood to be in a proper subset relationship. To see how the $more_1$ interpretation is ruled out, first consider again the semantics for $more_1$ applied to sets Q_1, Q_2 and Verb Phrase P. The semantic denotation of *more* Q_1 *than* Q_2 P is shown in (316). Now suppose that, through lexical/conceptual knowledge, it is known that $Q_2 \subset Q_1$. From this knowledge, it follows that $Q_2 \cap P \subset Q_1 \cap P$. This is the meaning of $more_2$, save for the additional information that $Q_2 \cap P$ is non-empty, as shown in (317).

(316) $[[More_1\ Q_1\ than\ Q_2\ P]] = \{d : Q_2(d) \cap P\} \subset \{d : Q_1(d) \cap P\}$

(317) $[[More_2\ Q_1\ than\ Q_2\ P]] = Q_2 \cap P \subset Q_1 \cap P$, where $Q_2 \cap P \neq \emptyset$

In order to account for the inability of sets that are in a lexical/conceptual proper subset relationship to be compared by $more_1$, we may have to appeal to a new pragmatic principle stating that if the subset part of the meaning of $more_2$ follows from world knowledge, then $more_2$ must be deployed. Testing the predictions of such a principle is left for future research.[8]

[8]Here I have shown that the two sets that are in a proper subset relationship are not compared using $more_1$. Could two overlapping sets be compared with $more_2$? It turns out that in such a case, $more_2$ would force the comparison of proper subsets. Say Q_1 partly overlaps with Q_2, as is likely to be the case with the *more lawyers than parents came to the party* example described above. In this case, applying the meaning in (i) to the example would not allow for such overlap, because if $Q_2 \cap P$ (or some parents who are not lawyers came to the party), then the proper subset relationship in (i) would return a value of false. Therefore, sets like *lawyers* and *parents* may only be compared with $more_2$ if they are understood to be in a proper subset relationship.

i. $[[More_2\ Q_1\ than\ Q_2\ P]] = Q_2 \cap P \subset Q_1 \cap P$, where $Q_2 \cap P \neq \emptyset$

In this section I have presented an account that allows *more (than)* to assert a subset relationship between two arguments having one of two semantic types: sets of degrees ($< d < et >>$) or sets of individuals ($< et >$). Asserting a subset relationship between sets of degrees corresponds to the typical, contrastive interpretation of comparatives, while a subset relationship between individuals gives rise to the subset comparative interpretation. This account has further implications that differ from the account presented in Section (5.4). For example, this new account does not rely on *just* in order to calculate the Subset Comparative Presupposition. Rather, the inclusion of *just* (or other similar element) would be a reflection of the choice of the meaning $more_2$ rather than an element that itself forces the subset comparative interpretation. This view is compatible with the availability of a subset comparative interpretation of comparative clauses without having to posit that these clauses are coerced into a DP meaning.

5.10 Conclusions

This chapter investigated subset comparatives, a type of comparative that has not been widely discussed in the linguistics literature (although they have been used in at least one other investigation, see example 36 in Chapter 1, from Fults and Phillips, 2004). Unlike contrastive comparatives like (318) and (319), subset comparatives do not have the function of comparing two sets and asserting that one is greater.

(318) More dogs than cats played fetch.

(319) I liked more people than I disliked.

Instead, subset comparatives seem to behave more like comparatives with overt degree standards, like (320). This kind of sentence might mean that more than two people came to the party (as in 321), or the speaker might have two people in mind who came to the party, in which case (320) could have a subset comparative meaning like (322). Instead of comparing two degrees or amounts, subset comparatives indicate that a given individual or individuals, or even a given *kind*, has the property at issue, plus one or more other individuals or kinds have that property, too.

(320) More people than (just) two came to the party.

(321) More than two people came to the party.

(322) More people than (just) Bob and Sarah came to the party.

Although typical comparative semantics (from DP-subcomparatives and Attributive NP-comparatives) comes close to the meaning of subset comparatives, in this chapter I showed that subset comparatives have an additional part of their meaning that unifies this class of comparatives. This meaning is a presupposition that the main predicate of the clause in which the comparative appears is true of the complement to *than*, which I call the Subset Comparative Presupposition. For subset comparatives like those discussed in Sections 5.2-5.7, the subset comparative interpretation was obligatory given the lexical or conceptual relationship between the standard and associate of comparison (e.g., *eagle* to *bird*) and possibly also because of the form of the complement to *than* (a full DP) or the presence of *just*. In Section 5.8, I discussed examples with comparative clauses that are ambiguous between a subset interpretation and a contrastive interpretation. Intuitively, when these examples are given a subset interpretation, it also holds that the main clause predicate is true of the complement to *than*. For example, in (323), the subset interpretation could be paraphrased as *Linda reported all of the crimes she directly witnessed, plus some others*.

(323) Linda reported more crimes than she directly witnessed.

The subset comparative clauses presented in Section 5.8 had comparatives in object position. However, subset comparatives are, I believe, also possible in subject position. Again in these examples, when a subset interpretation is construed, the Subset Comparative Presupposition seems to hold. In (324), if the *than*-complement is understood to be a subset (akin to *More crimes than just the ones Linda witnessed*), it is presupposed that those crimes were also reported in the newspaper.

(324) More crimes than Linda witnessed were covered in the local newspaper.

Beyond highlighting issues in the syntax, semantics and pragmatics of subset comparatives, this chapter also showed that subset comparatives can reveal facts about the processing of comparatives as well as sentence processing in general. Experiment 7 showed that readers did not immediately identify the lexical/conceptual subset relationship during on-line sentence processing. This result argues for an initial expectation toward disjoint sets in processing comparatives, which I call the Contrast Preference Hypothesis. More generally, this result supports a theory under which top-down expectations about the syntax and semantics of linguistic input has a more immediate effect than bottom up information from the specific lexical items encountered. Experiment 8 showed that when a truly disambiguating element, such as *just*, signaled the subset comparative meaning, then the lexical/conceptual information was integrated immediately. Somewhat surprisingly, the presence of *just* in the experiment was associated with a more immediate effect of the subset relationship even in the condition with *just* absent. This could be because subjects were primed to the presence of subset comparatives in the experiment overall, leading them to notice a potential subset interpretation earlier than they would have otherwise.

The discussion of subset comparative clauses in Section 5.8 suggests that the subset interpretation is not a last resort in order to understand sentences with an atypical lexical/conceptual relationship between the standard of comparison and the associate. Rather, there can be ambiguities between interpretations in sentences that have possible contrastive interpretations. Further research remains to be done into the factors that influence readers' interpretations of comparative clauses as subset or contrastive.

The support for the Contrast Preference Hypothesis in Experiments 7 and 8 invites the question of whether the preference for contrasting sets is specific to comparatives, or more general in nature. If the preference for disjoint sets is general, this would predict effects based on the relationship between sets in domains outside comparatives. For example, a preference for contrast would predict that readers/listeners would understand the sets *the lawyers* and *the parents* to be disjoint in (325-326). If this is true, then the continuation in (325), wherein the parents did not attend the party, may be more expected than (326), in which the sets may overlap.

(325) The lawyers went to the office party. The parents had to stay home.

(326) The lawyers went to the office party. The parents only had one drink.

The examination of subset comparatives has opened up a new empirical ground for examining preferences and default interpretations of relationships between sets in sentence processing. While this investigation focuses on the relationships between sets in comparative constructions, the results have implications for hypotheses regarding the interpreted relationships between sets in semantic and syntactic processing more generally.

CHAPTER 6

COMPARING SETS IN ON-LINE SENTENCE PROCESSING

6.1 Introduction

What does it mean to comprehend a comparative? The linguistic representation of a comparative specifies a set of truth conditions for the sentence that include an ordered relationship between two degree arguments, one in the associate of comparison and one in the standard of comparison. Example (327a), for instance, would have a semantics something like that in (327b), wherein it is asserted that the maximal number of people who came to the party is greater than the maximal number of people who I invited.

(327) a. More people than I invited came to the party.

b. $max(\lambda d\ d\text{-many people came to the party}) > max(\lambda d \text{ I invited } d\text{-many people})$

Another point of view to take is that understanding (327a) involves holding two sets in mind, the set of people who came to the party, and the set of people who I invited, and comparing these two sets on their cardinalities (i.e., the *size* of each set).[1] Depending on the context of the utterance, the hearer or reader may know the size of one or both sets being compared (for example if (327a) was uttered at the party in question, and could estimate the number of guests), or may have to represent the sizes of the sets and compare them without information as to the exact value of either one.

This chapter investigates the complexity involved in comprehending comparatives, or more specifically the complexity involved in determining the values to be compared in composing a well-formed representation of a comparative at the semantic level (and possibly the pragmatic level as well). This aim will be achieved by examining the processing of *cardinality* comparatives like (327a), and *degree* comparatives, which I will define below. Up to this point, this dissertation has focused on comparatives like (327a) and (328), where the comparisons at issue involve cardinalities.

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[1]Here I will use *cardinalities* to refer to the size of sets of countable entities, and I will reserve the term *amounts* to speak of comparisons of mass quantities. I will return to this distinction in Section 7.

(328) More bears than eagles were found in the conservation area.

Representing and accessing information about the cardinalities of sets is not enough to comprehend comparatives in general, however. The canonical examples of comparatives involve comparisons not of cardinalities or amounts of entities, but rather of degrees on an adjectival scale, as in (329).[2]

(329) The piano is heavier than the saxophone.

max d(the piano is d-heavy) > max d(the saxophone is d-heavy).

Understanding comparatives like (329), which I will refer to as a *degree comparative*[3], involves comparing the degree that each of two individuals holds along an adjectival scale. In order to understand (329), the reader or hearer must compare the value of the piano to the value of the saxophone on the scale of heaviness (or *weight*).

In theoretical linguistics, cardinality and degree comparatives have generally been assumed to have the same underlying structure and semantics, with *many* having the same semantic type as a scalar adjective like *heavy* (shown in 330-331) (e.g., Bresnan, 1973). I will tentatively assume this meaning for *many*, although in Section 6.4 I will discuss an alternative account by Hackl (2001a,b).

(330) $[[many]] = \lambda d.\lambda x.\ |x| = d$

(331) $[[heavy]] = \lambda d.\lambda x.\ x$ is d-heavy

In addition to examples like (329), which compares the degrees of two individual entities along the scale of heaviness, degree comparatives can also compare plurals, requiring a comparison of the values of sets on a scale. The interpretation of such a comparative, however, is not quite straightforward. For example, (332) involves comparing a set of boxes to a set of crates on the scale of *heaviness*. But how are the sets compared, given that each set might contain a heterogeneous assortment of boxes? There are several ways in which this comparison could be computed, giving rise to

[2]For now, I will leave aside the more complex case of subcomparatives, wherein degrees along two separate scales are compared.

[3]I will use the terms *cardinality* and *degree comparatives* in this chapter to distinguish between comparisons of set size vs. degrees on an adjectival scale. These terms are independent of whether or not cardinality comparatives involve the semantic type *degree* in their representations (which I tentatively assume to be the case).

multiple interpretations for sentences like (332). These meanings will be discussed in Sections 6.3 and 6.5. [4]

(332) The boxes are heavier than the crates.

max d(the boxes are d-heavy) > max d(the crates are d-heavy).

The possible meanings of examples like (332) map on to verification strategies that can be used to compute the truth or falsehood of the sentence. One possibility would be that comprehenders compare members of each set pairwise to determine whether the relevant ordering of each pair holds (as advocated by Matushansky and Ruys, 2006), for example for (332 this would mean comparing box-crate pairs to verify whether for that pair, the box is heavier than the crate. Another recent proposal claims that comprehenders compute a mean degree value of all members of a set, and compare these mean values (Scontras et al., 2012, discussed in more detail in Section 6.3).[5] What these strategies have in common is that they require access to the degree values of individual members of each set. Critically, to comprehend cardinality comparatives, accessing the properties of individual set members is not required. Here I will explore the idea that due to this difference in the extent to which individual set members must be accessed, comprehending degree comparatives like (332) is a more complex operation than comprehending superficially similar cardinality comparatives.

In this chapter, I will investigate the complexity involved in processing cardinality and degree comparatives like (333a) and (334a) during on-line sentence processing. Research into how plurals

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[4]In addition to the factors discussed in the following sections, there may be other factors, like the choice of predicate for instance, that influences the reading of degree comparisons of sets. Schwarzschild (2009) observes that some predicates to be 'stubbornly distributive', in the sense that they must distribute over members of a plurality rather than being understood as a collective property. As shown in (i-ii), *heavy* is compatible with either collective or distributive interpretations (all of the boxes together are heavy, or each individual box is heavy), while *large* lacks the collective reading. These properties of adjectives may have an effect on how comparatives that use them are understood.

i. The boxes are heavy. ⇒ *collective or distributive*

ii. The boxes are large. ⇒ *distributive only*

[5]While Section 6.3 presents evidence from verification of comparative statements with respect to a visual presentation, one might also expect to find differences with respect to incremental processing for the different verification procedures. A mean value for the properties of members of a set could be immediately computed for each set as it is processed, while pairwise comparison would require representing the degree values of all members of the first set until they could be pairwise compared with the second set. This difference will be taken up in slightly more detail in Section 6.5.

are represented, along with facts from studies of visual verification of comparatives, motivate the hypothesis presented in Section 6.5 that degree comparatives such as (334a) should incur processing difficulty over and above what is found for (333a). This difficulty is predicted to exist despite the assumed similarities in the semantic (Logical Form) representations between cardinality and degree comparatives, as shown below examples in (333b-334b). This hypothesis, which I call the *Degree Complexity Hypothesis*, is tested in a study of eye movements during reading, presented in Section 6.6.

(333) a. *Cardinality*: John lifted more boxes than Bill lifted.

b. *max* (d: John lifted d-many boxes) > *max* (d': Bill lifted d'-many boxes)

(334) a. *Degree*: John lifted heavier boxes than Bill lifted.

b. *max* (d: John lifted d-heavy boxes) > *max* (d': Bill lifted d'-heavy boxes).

Before fleshing out the hypothesis as it pertains to the experiment, I will review some of the literature on the broader topics that are essential to this investigation. These topics include the representation of sets in language and sentence processing in general, and specifically the representation of sets in language processing (discussed in Section 6.2.2). Here the notion of 'representation' can be used to refer to representations at several different levels. A representation in the general cognitive sense might be a mental picture or some other idea about the nature of a set, while a formal linguistic representation might be a function leading to a value of 'true' for an input if and only if that input meets the inclusion criteria for the set (see Heim and Kratzer, 1998). Both senses of 'representation' are relevant to the investigation undertaken here, so I will be as explicit as possible in signaling which one is meant at each juncture. Section 6.3 presents evidence on how people verify statements with comparatives and comparative quantifiers (e.g., *most*) when presented with visual arrays, and what that might say about both verification strategies and the underlying linguistic representation of comparative morphology. In addition to discussing the mental representations of sets and the verification of comparative statements, I will also discuss possible differences in complexity between semantic types, based on evidence from the typology of comparatives (Section 6.3.1), and potential differences in the linguistic representation of cardinality and degree comparatives that have been proposed in the literature (Section 6.4). This background will both motivate the experimental hypotheses and inform the interpretation of the experimental results presented later in the chapter.

6.2 The representation of sets

6.2.1 Representing and modifying sets

Forming, altering and employing internal representations of sets of objects is an essential part of understanding the world and communicating with others. Some sets gain an internal representation including, say, visual or auditory information, because they are or were present in the perceptual scene. For example, if you have a number of pencils on a desk in front of you, you are likely to have in mind the set described by the DP *the pencils on the desk*. Other sets might have an accessible representation because they form categories that we have learned through our experiences. For example, most adults would know the possible members of the set described by *birds* in the sentence *Birds sing* because they have learned what it means to be a bird in school or through general experience.[6] However, language can describe novel sets that aren't represented in the scene or in our conceptual knowledge, and this linguistic description can give rise to a mental representation of what the members of that set might look or sound like through imagination. In (335), the set described by *the cobalt blue labrador retrievers* is unlikely to have any members in the actual world, but we can still understand the sentence and also refer back to that set's description using a pronoun, showing that the set can be used as a discourse referent. Hearing or reading the description of the discourse referent may cause the comprehender to also form a mental picture of what a blue labrador might look like.

(335) [The cobalt blue labrador retrievers] enjoy sailing. They find it invigorating.

The question remains as to where the linguistic representation of sets ends and our conceptual representations begin. In the psycholinguistic literature on the representations of plurals, there has been a focus on the cognitive aspects of the representation of sets. In the next section, I will review the literature on the representation of plurals and the ease of access of individual members of sets. The question of how humans make decisions based on mental representations of visually present sets as opposed to those evoked from conceptual knowledge or imagination will be discussed further in Section 6.3.

[6] Although, *kinds* in the sense of Carlson (1977b) may have a distinct semantic type from other sets.

6.2.2 Representing and accessing members of sets

In order to understand the process of comparing sets, it is important to understand what insights have been found regarding the comprehension of plurals in general. The psycholinguistic literature has focused mainly on how plurals are represented in a cognitive sense, or more specifically to what degree atomic members of sets are represented depending on how a set is introduced and referred to in language. The degree of internal structure that is represented in plurals in turn determines the extent to which individual set members are accessible in language processing, for example how costly it is to refer to an atomic set member using an anaphor (e.g., Eschenbach et al., 1989; Moxey et al., 2004) or whether individual members of a set can be participants in a reciprocal verb meaning (Patson and Warren, 2011). From a linguistic perspective, semanticists have debated whether plurals should be formalized as sets or as (complex) individuals (see discussion in Schwarzschild, 1996). In this section, I will review some of the literature regarding how sets are represented (cognitively and linguistically) and how individual set members are accessed during on-line language processing. This background on the cognitive and linguistic representations of sets will inform the hypotheses for set comparison in the experiment presented in Section 6.6.

There is now a body of evidence that the way that a set or plural entity is introduced and referred to in language has an effect on how the individual members of that set are represented. An early finding in this line of research comes from Murphy (1984). Murphy showed that the time course of processing plural DPs (as shown by sentence reading times) depends on how the set has been introduced, with implications as to how sets are represented. Murphy concludes that plural NPs, such as *houses*, can refer either to several individual entities in a discourse model (collected as a set), or can refer to an undifferentiated set that forms a single discourse entity. As an example, consider Murphy (1984)'s Experiment 4. In this study, subjects were presented with stories such as (336) and (337) sentence-by-sentence in a self-paced reading task. The critical sentence (shown in bold) was identical for the two conditions and contained a plural NP (*the houses*). However, in (336) this same plural NP refers to two separate entities introduced previously into the discourse, while in (337) the plural is presented as undifferentiated throughout the story. Murphy found a 141ms advantage for critical-sentence reading times in the undifferentiated condition. This result that processing a plural that collects together multiple distinct entities through a plural referent is costly compared to processing a plural that refers to an undifferentiated set.

(336) Linda was looking for a new house.

There were a lot of houses for sale in her town.

She visited a house with a fireplace in every room.

Another was a block away from the train station.

The houses were far too expensive, however.

She decided to stay in her old place after all.

(337) Linda was looking for a new house.

There were a lot of houses for sale in ther town.

She visited several houses with fireplaces in every room.

They were just several blocks away from the train station.

The houses were far too expensive, however.

She decided to stay in her old place after all.

Murphy (1984)'s study involves the use of definite DPs in order to refer to the set(s) that are either set up as being composed of multiple discourse referents or of a single, plural discourse referent. Plural sets that have internal structure have been called *complex reference objects* (Eschenbach et al., 1989; Kamp and Reyle, 1993; Moxey et al., 2004). In other words, complex reference objects are sets that have individuated set members (much like *the houses* in 336). For example, a set may be introduced by coordinated singular NPs, for example *John and Mary*. The complex nature of the representation of coordinated phrases like *John and Mary* has been shown through studies of anaphoric reference. Koh and Clifton (2002) found that readers were more likely to understand a plural pronoun as referring to a particular set when that set was made up of similar entities (e.g., humans), and that the form of the introduced set had an effect on what entities were considered to be a part of the object referred to by a pronoun. For example, reading time data showed an interaction such that a penalty for referring to only two out of three participants in a context sentence with a pronoun was eliminated when the predicate used to introduce the participants was non-symmetric. For example, using a pronoun like *they both*, which must refer to a set with two members only, showed a penalty when the verb was symmetric (e.g., *John sang with Jim and Tony* in 338 entails that Tony and Jim sang with John) as compared to referring to two entities out of the three introduced in (339), where the verb *recognize* is not symmetric. This study showed that mentioning multiple entities together might not be enough to form a complex reference object; but rather the way in which the potential set members are introduced is essential.

(338) John sang with Jim and Tony.

(339) John recognized Jim and Tony.

With a similar goal to Koh and Clifton, Moxey et al. (2004) performed an experiment examining subjects' continuations after prompts like (340a-340c). Moxey et al. found that subjects provided continuation sentences containing plural anaphora on a majority of trials to prompts like (340a), which introduced a set through coordinated subject NPs. There were fewer plural anaphor continuations to sets introduced with *with*, which retained the co-agent status of the NPs but were outside of a coordinated phrase, and fewer still with *for*. Within coordinated NPs, Moxey et al. (2004) found that subjects provided more plural continuations when two proper names were coordinated as opposed to one proper name and one definite description.

(340) Moxey et al. (2004):3-5

a. Jack and Jill painted the lounge.

b. Jack painted the lounge with Jill.

c. Jack painted the lounge for Jill.

While the reading time and completion studies discussed above show that the way in which set members are described is important to the formation of a complex reference object, it is less clear whether these differences in set formation affect normal reading times of plural anaphora that refer to complex reference. Clifton and Ferreira (1987) failed to find differences in reading times of plural pronouns based on properties of the plural antecedent in self-paced reading. Moxey et al., using eyetracking, found facilitation for plural anaphora referring to individuals conjoined with *and* over those linked by a Prepositional Phrase headed by *for* on the final region of the target sentence, in First Pass and Go-Past Time[7].

[7]NPs linked by *with* showed equivocal results, patterning with *for* in First Pass Time and *and* in Go-Past Time.

The studies described above in this section address questions in the formation of sets or complex reference objects. There have also been studies testing the complexity of accessing individual set members from these objects. While facilitation for plural anaphora with coordinated NP antecedents has only been found in some studies, the penalty for singular anaphora that refer to an individual member of a complex reference object has been shown in reading time measures including whole sentence reading time and eyetracking (Garrod and Sanford, 1982; Albrecht and Clifton, 1998; Moxey et al., 2004). For complex referents introduced by conjoined entities, this effect has been called the *conjunction cost*. However, Koh et al. (2008) eliminated the conjunction cost from whole-sentence reading times by using predicates that are normally performed by one individual on behalf of the group. A conjunction cost was shown for singular pronouns in sentences like (341a), but not for sentences like (341b), where norming data indicated that one person would be likely to perform the action for the plurality. Koh et al. also found that a repeated name penalty was eliminated for predicates like (341b) when a proper name was substituted for the pronoun (although repeated name penalties may not always appear for names previously mentioned in a coordinated phrase (Gordon et al., 1999)). However, Koh et al. (2008) used only whole sentence reading times, so it is possible that looking at reading times in the region before the helpful predicate, a local conjunction cost could be present in both experimental conditions with a faster recovery in the condition corresponding to (341b).

(341) Koh et al. (2008): 5,7

a. Last night John and Mary went to an Italian restaurant. He/They really enjoyed the food.

b. Last night John and Mary went to an Italian restaurant. He/They asked for a table.

Taken together, the results of these studies show that readers do build plural/complex reference objects from NPs introduced in coordinated structures, and that although there may be a cost in doing so, individual members of these plurals can be accessed and are therefore a part of the representation. However, there are several factors, for example the form of the coordinated NP/DPs, that can influence the accessibility of the individuals that make up the plural reference object.

Like the studies finding the conjunction cost, Patson and Warren (2011) studied the representation of plurals by how their individuals are accessed. However, rather than using pronominal reference to a set member, Patson and Warren investigated the extent to which individual set members are salient or accessible by testing when these might be taken to be participants in an event described by a reciprocal verb. Previous research (e.g., Johnson-Laird, 1983) has suggested that sets are represented as non-individuated groups in the general case (e.g., when a set is not introduced with a conjoined phrase or other 'individuating' structure), but the above studies have shown that representations of plurals *can* be complex, and individual set members can be differentiated in a plural's representation.

Patson and Warren present eye-movement studies with experimental materials based on the paradigm used by Patson and Ferreira (2009), who found that garden path effects in sentences like (342a) could be mitigated if both the first verb can be understood as reciprocal (e.g., *kissed*) and the subject of that verb was a conjoined NP, as in (342d). Merely having a plural DP as a subject (e.g., *the lifeguards*) was not enough to invite the reciprocal interpretation, suggesting that sets referred to without any individuation (for example, as introduced by a conjoined NP) are represented as undifferentiated.

(342) Patson and Ferreira (2009)

a. While the lifeguards trained the child fell into the pool.

b. While the lifeguard and the swimming instructor trained the child fell into the pool.

c. While the lifeguards embraced the child fell into the pool.

d. While the lifeguard and the swimming instructor embraced the child fell into the pool.

Patson and Warren present a series of three eyetracking experiments testing conditions under which set representations are more than simply undifferentiated set, and therefore the conditions under which individual members of sets can be (easily) accessed. In their experiments, the sets were introduced in a context sentence prior to the target sentence, which potentially contained a garden path. Patson and Warren found in their first experiment that First-Pass reading times on the critical region of the target sentence were shortest with the reciprocal verbs when the context sentence attributed different properties to each of the set members rather than the same property. The properties of set members were introduced by appositive modifiers such as *Two trainers, one new and one experienced*, or *Two trainers, both new and inexperienced*. Sample materials are shown in (343).

(343) Patson and Warren (2011): 7-8

a. Two trainers, one new and one experienced, were near the swamp.

b. Two trainers, both new and inexperienced, were near the swamp.

i. While they wrestled the alligator watched them closely.

ii. While they walked the alligator watched them closely.

In addition to attributing different properties to the set members, assigning the set members two distinct values on a given scale were found to make the individual set members more accessible, again as shown by the lack of a garden path for reciprocal verb targets. The contexts ascribing two different degree values were introduced using a comparative modifier (e.g., *one newer than the other* in 344a) in the context sentence, while the nondistinct degree conditions used a simple restrictive relative (e.g., *who were new to the zoo* in 344b).

(344) Patson and Warren (2011):10-11

a. Two trainers, one newer than the other, were near the swamp.

b. Two trainers, who were new to the zoo, were near the swamp.

Last, Patson and Warren showed that individual set members were easier to access when an attribute is assigned to only one set member (345a) as compared to attributing the same property to the two set members (345b).

(345) Patson and Warren (2011):12-13

a. Two trainers, one of whom was new, were near the swamp.

b. Two trainers, both of whom were new, were near the swamp.

The results of Patson and Warren (2011)'s studies indicate that when individual members of a set are modified in such a way as to give them separate properties (or separate degrees along an adjectival scale, as in the case of Experiment 2), the set members are more readily accessible, as shown by the increased availability of a reciprocal interpretation of critical verbs like *kissed*. A secondary result, that the plural pronoun in the target sentences showed differences in some eye movement measures depending on whether it referred to a sets whose members had been referred to individually as opposed to those that had not, is compatible with the results of Murphy (1984). This effect was apparent in First Pass Time in their Experiment 1, in the proportion of Regressions Out of the pronoun region in Experiment 2, and in both measures in Experiment 3. The authors interpret the penalty on the pronoun as an increase in difficulty or complexity in forming a pronominal reference to a plural antecedent with individuated members.

Two main conclusions emerge from the literature on the representation and processing of sets. First, using a plural NP/DP or anaphor to refer to an undifferentiated set causes less processing difficulty than referring to a complex, individuated set. Second, in the absence of explicit individuating information, such as the use of a conjoined NP to describe a set (Patson and Ferreira, 2009) or the use of modifiers to attribute distinct properties to set members (Patson and Warren, 2011), sets are represented as undifferentiated.[8] Relating these conclusions to the question of how sets are compared during the processing of comparatives like (346) and (347), repeated from above, the preference for an undifferentiated plural representation might facilitate comparisons of (approximate) cardinalities over comparisons of degrees because comparing cardinalities does not involve attributing any attributes to individual set members. Degree comparison, on the other hand, requires that the individual members of a set have a degree value along a given adjectival scale, which may or may not be identical for all set members. This idea will be expanded in Section 6.4.

(346) *Cardinality*: John lifted more boxes than Bill lifted.

(347) *Degree*: John lifted heavier boxes than Bill lifted.

6.3 Visually verifying comparatives and comparative quantifier statements

Recently, there have been experimental investigations into how the truth values of statements that require the comparison of sets are verified. Here I will discuss two such studies that investigate verification of statements with *comparative quantifiers*, e.g., *most* (Hackl, 2009b; Pietroski et al., 2009), and one study, which is more directly relevant to the experiment described in Section 6.6, that involves using degree comparison (Scontras et al., 2012).

Comparative quantifiers like *most* and *more than half* are verified with respect to a visual array of objects (typically dots). Hackl (2009b) presents a series of experiments using a novel experimen-

[8]Further evidence in support of this conclusion from a picture verification task was presented by Patson et al. (2012).

tal paradigm to show that while their truth values are identical, there are differences in the strategies with which people verify statements with *most* and *more than half*. Hackl argues for an analysis of *most* as composed of *many* and the superlative morpheme *-est*. This analysis predicts that the (simplified) interpretation of proportional *most* should be as in (348). *more than half*, on the other hand, should have an interpretation as in (349), that better reflects its morphological make-up.

(348) Hackl (2009b): 49b

$[[most]](A)(B) = 1 \text{ iff } |A \cap B| > |A - A \cap B|$

(349) Hackl (2009b): 47b

$[[more\ than\ half]](A)(B) = 1 \text{ iff } |A \cap B| > \frac{1}{2}|A|$

In Hackl's self-paced counting paradigm, subjects heard auditory statements with *most* and *more than half* (e.g., *most/more than half of the dots are blue*) and were presented with an array of uncoloured dots. Using a button press, subjects could reveal the colours of the dots two or three at a time. Subjects were instructed to judge the statement as 'true' or 'false' with respect to the dot array quickly and accurately. In the first experiment, the arrays included eleven dots and the colour distribution differed by only one dot. Hackl found that while accuracy was high for both *more* and *more than half*, subjects' reaction times to advance through the array were generally longer for *more than half* and generally became longer across the partial presentations of an array. Hackl's third experiment manipulated the arrangement of the coloured dots across the presentations, with the hypothesis that if the advantage for *most* over *more than half* in the original experiment was due to a 'lead-counting' strategy rather than counting up to half of the number of possible dots, then the relative ease of verifying *more* should be diminished when the dots of the target colour were stacked toward the beginning or end of the array.[9] The reaction time results showed that *most* had long reaction times in the condition in which the target dots were shown late in the array as compared to the early condition on several presentation regions, while *more than half* showed a difference according to presentation condition on only one screen. These results are interpreted as support for a lead-counting interpretation of *most*, akin to (348), and an interpretation of *more than half* like (349).

[9]Hackl (2009b)'s Experiment 3 also employed empty slots and distractors, making the task more difficult overall.

In another study testing the verification strategies used in judging the truth or falsehood of sentences with *most*, Pietroski et al. (2009) had subjects answer questions such as 'are most of the dots yellow?' with respect to rapidly presented (200ms) visual arrays of yellow and blue dots. The arrays varied in the proportion of yellow dots and the arrangement of the dots: scattered or in columns, paired or unpaired. In addition to the proportion and arrangement factors, Pietroski et al. also manipulated whether or not the average sizes of the dots of each colour were equal. The results of the experiment showed that subjects had at-ceiling accuracy for dots paired in columns (i.e., one column of each colour side by side, where the column with more dots was visually taller) across all of the proportions. The other conditions all increased in accuracy as the Weber Ratio (larger number/smaller number) increased. These results led the authors to conclude that subjects were using an Approximate Number System, a system that has been proposed to underlie psychophysical judgments. In the Approximate Number System, discriminability is linked to the Weber Ratio, wherein larger cardinalities much have larger differences in order to show the same discriminability (the example given by Pietroski et al. (2009) is that 6 and 12 are as easily discriminable as 60 and 120). The ANS conclusion is supported over other possible ways of interpreting *most*, including looking for one-to-one correspondences between dots, or employing the strategy that Hackl (2009b) supports for *more than half*. In related, work, Lidz et al. (2011) provided further support for the use of an Approximate Number System in verifying *most* statements. In their experiment, Lidz et al. (2011) used a similar paradigm to Pietroski et al. (2009) (although with an even shorter 150ms stimulus presentation), this time with arrays that had more than two colours. Lidz et al. (2011) replicated the effect of the ratio of dots of the colour in question (e.g., blue when the statement to be verified is *most of the dots are blue*) to dots of other colours, and the good model fit of the ANS model to the human data. In addition, Lidz et al. (2011) found a result that distinguished between two possible verification strategies. Lidz et al. present two possible strategies that people could have for verifying their experimental statements. One could be to approximate the cardinality of blue dots, approximate the cardinality of non-blue dots, and compare the two, corresponding to the representation in (350). The other possibility would be to approximate the total number of dots and the cardinality of the blue dots, and subtract the latter from the former, corresponding to the representation in (351).

(350) Lidz et al. (2011): 11a

$> (|DOT \cap BLUE|, |DOT - BLUE|)$

(351) Lidz et al. (2011): 11b

$> (|DOT \cap BLUE|, |DOT| - |DOT \cap BLUE|)$

In order to test between the strategies represented in (350) and (351), Lidz et al. varied the number of colours in the set of non-blue dots. Citing work from the literature on the estimation of cardinalities of objects in visual arrays showing that it is more difficult to pick out and estimate the cardinalities of heterogenous objects , they hypothesize that if subjects were using (350) to judge sentences, then accuracy should decrease with the number of colours shown. The experimental results, however, showed no such effect, lending support to a subtractive strategy for determining whether the *most* statements were true.

Lidz et al. (2011) provide a detailed discussion of their assumptions regarding the relationship between verification strategies and semantic representations. While they acknowledge that verification strategies might vary even for the same semantic representation (for example, if given enough time, people may explicitly count to determine cardinalities rather than estimating), there is a tendency to use verification strategies that reflect underlying semantic representations. They formalize this point of view as the *Interface Transparency Thesis*, reproduced in (352).

(352) *Interface Transparency Thesis* (Lidz et al., 2011):

The verification procedures employed in understanding a declarative sentence are biased towards algorithms that directly compute the relations and operations expressed by the semantic representation of that sentence.

Further support for the Interface Transparency Thesis is provided by Tomaszewicz (2011). Tomaszewicz used a rapid visual presentation verification task, similar to Lidz et al. (2011), to test verification strategies for two Polish quantifiers, *większość* and *najwięcej*. While *większość* has a proportional meaning like English *most*, Tomaszewicz translates *najwięcej* as 'the largest subset'. The experimental results replicated Lidz et al. (2011)'s results for *większość*, that the number of distractor colours in the display did not affect accuracy judgments, while the ratio of the target to non-target dots did. For *najwięcej*, however, the number of distractor colours did have an effect in addition to the effect of ratio, showing that the non-target sets had to be selected in order to verify the statement, and therefore supporting the hypothesis that the semantics of the quantifier influenced the strategy used to verify statements with that quantifier.

Recently, Scontras et al. (2012) extended the research linking verification strategies to semantic representations to the comparison of pluralities. Scontras et al. investigated the representation of sets through a pair of experiments examining how readers verify sentences comparing plurals with respect to a visual array (following similar studies with quantifiers like *most*, Pietroski et al., 2009). The dot displays were constructed in order to tease apart the predictions of a model that used point-wise comparison of dot sizes Matushansky and Ruys (2006) to ones that used aggregate values such as the mean (or sum, in Experiment 2) of set sizes. In their Experiment 1, the mean difference in dot size was varied in the materials, as was the distribution of sizes among the dots. For example, the experiment included a displays in which each blue dot was smaller than some red dot, and in which one red dot was smaller than every blue dot. Subjects were presented with these displays and were asked to judge “Are the red dots bigger than the blue dots?". The results suggested that a probabilistic model where the mean size of the dots in a colour set is compared best fit the pattern of subjects’ “yes” responses. In their second experiment, Scontras et al. invited different strategies in verifying the comparative statements by manipulating the cardinality of dots in the display, and also by decreasing the difference in the mean size of the dots in each set. However, the probabilistic mean-based model proved to be the best fit to the human data.

Scontras et al. draw from their data a conclusion regarding the representation of plurals. They suggest that plurals must have representations above the level of the individual set members that can be assigned their own properties (which they claim to be counter to Schwarzschild, 1996; Landman, 1996). From the studies cited above, (e.g. Patson and Ferreira, 2009; Patson and Warren, 2011), it seems that at least in processing the default representation of a plural discourse entity is one of an undifferentiated set, and that individual set members are only represented if they have been referred to directly or ascribed separate attributes.[10] One would expect that a visual representations of sets like the ones presented by Scontras et al. would make the individual set members especially salient.

[10]This idea may also be supported from evidence from language acquisition, where Zapf and Smith (2008) found that children were more likely to produce a plural form for sets that had identical members than for sets whose members fit into a basic-level category (e.g., *dog*) but were non-identical.

What Scontras et al. show is that subjects are able to generate a set-level property from properties of the individual set members, for example by computing their mean on a given scale. Even when the full array of set members is presented visually, it is a whole set-level attribute that is preferentially used in judging the truth-values of plural comparisons.

6.3.1 Semantic Types and complexity

Some work on cross-linguistic variation in comparatives has suggested that languages vary in the extent to which they encode degrees as a semantic type (if they encode them at all). With other linguistic phenomena, such as superiority effects, it has been found that what might be a grammatical distinction for one language can surface as a more subtle distinction - a preference or difference in processing complexity - in another language (Häussler et al., under review). In this section, I will review some of the arguments for the non-universality of degrees as a semantic type, with the suggestion that in languages that do represent degrees, this typologically special semantic type may influence processing complexity.

In their cross-linguistic survey, Beck et al. (2009) examine the evidence for degree variables and lambda abstraction over degrees in a sample of fourteen languages. They elicited target structures from all of the languages in the sample using a translation task and verifying the elicitations with native speakers. The targets included positive adjectives, comparatives (predicative, attributive), comparative with a degree standard (e.g., 353) and measure phrases (e.g., 354). The authors also checked to see whether the scope ambiguity observed by Heim (2000) was present for comparatives with certain modals. Heim observed that (355) is ambiguous between a surface scope (*required* > *-er*) reading, wherein it is understood that the paper must be 15 pages long exactly, and a reading where the comparative morpheme *-er* takes scope over *required*, wherein 15 pages is understood as a minimum length requirement. This test was included in the survey as a test of whether languages have abstraction over degrees, because the inverse scope reading requires such abstraction.

(353) Beck et al. (2009): 48a

Captain Apollo is taller than 1.70m.

(354) Beck et al. (2009): 48b

Helo is 8cm taller than Starbuck is.

(355) Heim (2000): This draft is 10 pages long. The paper is required to be exactly 5 pages longer than that.

Beck et al. identify groups of languages that systematically lacked a combination of the target structures from the questionnaire. The authors propose that these groups arise from the settings of three linguistic parameters having to do with the representation of degrees. The first of these has to do with whether or not a language represents degrees in its semantics (the *Degree Semantics Parameter*, defined in 356). The others state that languages vary with respect to whether they allow abstraction over degrees (the *Degree Abstraction Parameter*, defined in 357) and whether there can be overt material in the specifier of DegP (The *Degree Phrase Parameter*, defined in 358).

(356) Degree Semantics Parameter (DSP):

A language {does/does not} have gradable predicates (type $< d, < e, t >>$ and related), i.e. lexical items that introduce degree arguments.

(357) Degree Abstraction Parameter (DAP) (Beck et al. 2004):

A language{does/ does not} have binding of degree variables in the syntax.

(358) Degree Phrase Parameter (DegPP): The degree argument of a gradable predicate {may, may not} be overtly filled.

The only language in Beck et al.'s sample that is proposed to lack degrees (or a -DSP setting of that parameter) in its semantic representations is Motu, spoken in Papua New Guinea. Motu has what Stassen (1985) classifies as a 'conjunctive' type of comparatives. An example is presented in (359). This type of comparative is expressed through conjunction of two clauses, one that contains the compared constituent and one that contains something like a standard of comparison. Beck et al. reach the conclusion that Motu does not represent semantic degrees because Motu lacks comparative morphology and does not exhibit comparatives with degree standards (like 353) or comparatives with measure phrases (like 354).

(359) Mary na lata, to Frank na kwadogi.

Mary TOP tall, but Frank TOP short.
'Mary is taller than Frank.'

Bochnak (2011) proposes that Washo (spoken in Nevada/California) is another example of a degree-less language, citing evidence that Washo also lacks measure phrases, and that Washo comparatives meet the definition of implicit comparison in Kennedy (2007a).

(360) Bochnak (2011):12

t'éːliwhu de-ʔil-káykay-iʔ k'-éʔ-i šáwlamhu
man NMLZ-ATTR-tall-ATTR 3-COP-IPFV girl
de-ʔil-káykay-iʔ-éːs k'-éʔ-aʔ-š
NMLZ-ATTR-tall-ATTR-NEG 3-COP-AOR-SR

'The man is taller than the girl.'(lit: 'The man is tall, the girl is not tall.')

While the evidence for languages that lack degrees is still limited (Beck et al. provide only one example in this class, and (Bochnak, 2011) only discusses one of the types of comparatives in Washo), this evidence does suggest that the intense diversity of the forms of comparison in language does reflect underlying semantic differences. If the parameters proposed by Beck et al. are correct, then it follows that degrees are quite different from other semantic types. For example, no language to my knowledge has been proposed to lack lexical items that introduce individual (type *e*) arguments or propositions (type *t*). The non-universal status of degree variables could indicate that the presence of degrees in a linguistic construction in a language that *does* encode them could cause an increase in complexity for that construction.

6.4 Cardinalities and degrees in language

The goal of this chapter is to motivate and test the hypothesis that processing degree comparatives is more complex than processing cardinality comparatives. In the previous section, I speculated that degrees as a semantic type may cause processing complexity over other types, drawing on increasing evidence that the encoding of the semantic type *degree* may not be a linguistic universal. In this section, I will discuss similarities and differences in linguistic representation that have been proposed to exist between the two types of comparatives, and the distributional evidence that could be used as evidence for underlying distinctions between cardinalities and degrees in comparatives.

6.4.1 The meaning of *many*

Determining whether cardinality comparatives truly do have the same underlying semantic representation as degree comparatives rests in large part on the meaning of *many* (and by extension, *few*). Since Bresnan (1973), researchers working on comparatives have assumed that *more* is decomposable into *many* and the comparative morpheme *-er*. Generally, *many* has been thought to have a meaning like that of any other scalar adjective, taking a degree argument d and asserting that a (plural) entity x has cardinality d, as shown in (361). Under this analysis, the structure and semantics for comparatives involving cardinalities could be identical to those for comparatives involving other scalar adjectives, giving sentence (327a) the semantic representation shown in (362).

(361) $[[many]] = \lambda d.\lambda x.|x| = d$

(362) More people than I invited came to the party.

max d(d-many people came to the party) > max d'(I invited d'-many people)

In work previous to the experimental investigation cited above, Hackl (2001a,b) proposed that the semantics of what I have called cardinality comparatives (involving *many* and *few*) as well as *most* should be unified with the representation of other comparative quantifiers (e.g., *more than half, more than three*). However, in unifying comparative quantifiers and cardinality comparatives, Hackl must distinguish the semantics of cardinality comparatives from that of comparatives with other gradable adjectives. While he gives a familiar semantic representation for scalar adjectives as a function from individuals to degrees (shown in 363), Hackl analyzes *many* as a 'gradable (or *parametrized*) determiner' that takes one argument that is a degree of cardinality[11] and two arguments of type $< et >$ (shown in 364).

(363) $[[tall]] = \lambda d \in D_{height}.\lambda x \in D_e.x\ is\ d - tall$

(364) $[[MANY]] = \lambda d \in D_{Card}.\lambda f \in D_{<et>}.\ \lambda g \in D_{<et>}.\exists x\ f(x) = g(x) = 1\ \&\ x\ has\ d - many\ atomic\ parts.$

In the next section, I will examine the evidence as to whether the theory of the meaning of comparatives should include a semantic distinction between comparatives involving *many* and those

[11] Hackl includes in his semantics restrictions that the degrees (whether of cardinality or of some other scale) be order-preserving, a restriction I leave out here for simplicity.

with other scalar adjectives. I will discuss similarities between the comparative types as well as differences, including Hackl's evidence for grouping cardinality comparatives together with comparative quantifiers and not with degree comparatives, as well as other distinctions found in the literature.

6.4.2 The distribution of cardinality and degree comparatives

In a variety of languages, the analysis of cardinality comparatives as being the same as degree comparatives is supported by the use of the same syntactic machinery to communicate both types of comparatives. In English (365) and Japanese (366), cardinality and degree comparatives look very similar (although later in this section I will show some evidence from Hackl (2001a) that there are some differences between English cardinality and degree comparatives).

(365) a. I saw more students than professors.

b. I saw taller students than professors.

(366) Bhatt and Takahashi (2011a): 45b, 46a

a. Taroo-wa [Hanako-yori(mo)] ooku-no hon-o yonda.
Taroo-TOP Hanako-than many-GEN book-ACC read.
'Taro read more books than Hanako.'

b. Taroo-wa [Hanako-yori(mo)] omosiroi hon-o yonda.
Taroo-TOP Hanako-than interesting book-ACC read.
'Taro read a more interesting book than Hanako.'

This similarity does not appear to hold only for the most studied languages in the comparatives literature. Kuo and Sung (2010) show that cardinality and degree comparison are expressed similarly in at least two of the four types of comparatives attested in Amis, and Austronesian language spoken in Taiwan. Kuo and Sung describe an'exceed'-type comparative (using the terminology of Stassen, 1985), as shown in (367a), where the morpheme *-ki-* is added to a predicate to indicate an 'exceed' reading, and what the authors call *ikaka/isafa* comparatives, which employ a word, *ikaka* or *isafa* that is glossed by Kuo and Sung as 'more'. In these two types of comparatives, we see that *adihay* (‘*many*’), can be substituted for any other scalar adjective to make a cardinality comparative.[12]

(367) Kuo and Sung (2010):38

a. mi-ki-ratal ku pi-nengneng aku cingranan [tu pi-nengneng nira
AF-exceed-early NOM PI-see 1SG.GEN 3SG.OBL
takuwanan].

‘I saw him earlier than he saw me.’

b. mi-ki-adihay ku ∅-tayni-ay a fayinayan [tu ∅-tayni-ay a
AF-exceed-many NOM AF-come-AY LNK man OBL AF-come-AY LNK
fafahi’an]
woman
‘ More men than women came’

(368) Kuo and Sung (2010): 39

a. ∅ikaka ku ratal nu pi-nengneng aku cingranan [tu pi-nengneng
AF-more PI-see GEN PI-see 1SG.GEN 3SG.OBL OBL PI 3SG.GEN
nira takuwanan].
1SG.OBL
‘I saw him earlier than he saw me.’

b. ∅-ikaka ku adihay nu ∅-tayni-ay a fayinayan [tu ∅-tayni-ay a
AF-more NOM many GEN AF-come-AY LNK man OBL AF-come-AY LNK
fafahi’an]
woman
‘ More men than women came’

Despite the general similarities in the syntax of cardinalities and degree comparatives, the distribution of the two types may not be identical. Hackl (2001a) gives as evidence for the distinction

[12] However, as Kuo and Sung note, Amis does not have an equivalent DP-internal subcomparative structure to the English *More men than women came*.

between cardinality and degree comparatives the inability of *more* to appear in predicative position (except in some cases after the copula). If *many* had the same semantics as other gradable adjectives like *tall*, we would not expect the difference in grammaticality between (369a) and (b). To express cardinality comparatives in predicative form, one must use an adjective like *numerous*, as shown in in (370a).

(369) Hackl (2001a): 131

a. John looks tall.

b. *The guests look many.

(370) Hackl (2001a): 132

a. The Red Sox fans looked more numerous than the Yankees fans.

b. *The Red Sox fans looked more than the Yankees fans.

c. *While the Red Sox fans sent a large contingent, the Yankees fans looked fewer/less than 200.

The lack of cardinality comparison in predicative position may not hold cross-linguistically, however. In Hindi, *zyaadaa* ('many/more') can be used in predicative position. Example (371) shows such a cardinality comparative, which must be glossed in English with a nominal comparative.

(371) Hindi (example due to Rajesh Bhatt)

California-me	Texas-se	ciinii	log	zyaadaa	hẼ
California-in	Texas-than	Chinese	people	more	are

'There are more Chinese people in California than in Texas.'

If Hackl's analysis is correct, this difference in representation means not only that *more* (*many+er*) differs in its semantics from other scalar adjectives like *tall*, but that their arguments are represented differently as well. Hackl proposes that the arguments to *many* are pluralities (with atomic parts, in the sense of Link, 1983) rather than individuals. Therefore, the requirement for a plural complement to *more* is a semantic requirement as well as a syntactic one. Hackl supports this claim by showing that comparatives with *many* show some predicted restrictions with respect to the NPs and predicates that can co-occur. The NPs in question are those that denote individuals (e.g., *student*), those that denote plural entities (e.g., *colleagues*) and collective NPs that denote group-individuals (e.g., *committee*). Predicates can require individual arguments (e.g., *have blue eyes*), plural arguments (e.g., *were meeting*) or collective or group arguments (e.g., *constituted a minority*). These restrictions are shown in (372-374, from Hackl (2001b)).

(372) a. John has blue eyes.

b. Mary has blue eyes.

c. $\Rightarrow$ John and Mary have blue eyes.

(373) a. John and Mary were meeting.

b. Mary and Sue were meeting.

c. $\Rightarrow$John and Mary and Sue were meeting.

(374) a. John and Mary constituted a minority.

b. Mary and Sue constituted a minority

c. $\not\Rightarrow$ John and Mary and Sue constituted a minority.

d. $\Rightarrow$ John and Mary and Mary and Sue constituted a minority.

Comparatives with these NP/predicate combinations bear out the prediction that *many* takes pluralities as arguments. Examples (375a-d) show that both the individual and plural predicates are acceptable with *more* because they both take pluralities whose members are individuals. However, collective predicates cannot occur with a non-collective NP like *students*. The question for present purposes is then whether the argument of *more* is truly different from the argument of a comparative scalar adjective like *taller*. Equivalent examples to (375a-d) are shown in (376a-e). While the judgments must be verified, it seems that there could be differences at least one difference in the possibility of using collective predicates with plural NPs with *more* vs. other scalar adjectives (375b vs. 376b).

(375) a. More students have blue eyes/were meeting than Bill had expected.

b. # More students constitute a minority than Bill had expected.

c. #More committees have blue eyes/were meeting than Bill had expected.

d. More committees were meeting than Bill had expected.

e. More committees constitute a minority than Bill had expected.

(376) a. Taller students have blue eyes/were meeting than Bill had expected.

b. Taller students constitute a minority than Bill had expected. (ok?)

c. # Larger committees have blue eyes than Bill had expected.

d. Larger committees were meeting than Bill had expected.

e. Larger committees constitute a minority than Bill had expected.

Another potential argument for a linguistic distinction between cardinalities and degrees comes from Japanese. Although cardinality and degree comparatives take the same form in Japanese, subcomparatives of cardinality are grammatical (as shown in example 377), while it has been reported that subcomparatives of degree are ungrammatical or degraded (see example 378). This distinction could be a result of a difference in the availability of degree abstraction between English (which allows both types of subcomparatives) and Japanese (as per Beck et al. (2004)), but nonetheless serves as an example of a linguistic distinction between cardinality and degree comparison.

(377) Bhatt and Takahashi (2007): 55

Taroo-wa	[[Hanako-ga	hon-o	katta]	yori]	ooku-no	zassi-o	katta.
Taro-Top	Hanako-Nom	book-Acc	bought	than	many-Gen	magazine-Acc	bought

'Taro bought more magazines than Hanako bought books.'

(378) Beck et al. (2004): 5

Kono	tana-wa	[ano	doa-ga	hiroi	yori(mo)]	(motto)	takai.
this	shelf-TOP	[that	door-NOM	wide	YORI(mo)	(more)	tall.

'This shelf is taller than that door is wide.'

Evidence for syntactic differences between cardinality and degree comparatives is presented by McNabb and Kennedy (2011), using evidence from Palestinian Arabic.[13] McNabb and Kennedy show that for one type of comparative in Palestinian Arabic (those that use the standard marker *-ma*),

[13]McNabb and Kennedy use the terms *quantity* and *quality* for cardinality and degree, respectively.

there are differences between the two types of comparatives in the material that may be spelled out in the comparative clause. For cardinality comparatives, simple comparative clauses (379a) can have an internal noun spelled out whether it is identical to the associate of comparison, or a different noun (creating a subcomparative). If the noun is in an embedded clause within the comparative clause (379b), however, only a different noun can be pronounced. For degree comparatives, spelling out the noun in the comparative clause is never possible in attributive comparatives (380a-b) and spelling out the adjective phrase is not possible when the comparative clause is in a predicative comparative (380c-d).

(379) McNabb and Kennedy (2011):5

a. Comparison of quantity (non-embedded)

saʕed ʔakal baskut ʔaktar mi-ma ʔaklat muna {baskut/moz/∅}

Saed ate.3SM cookies more from-that ate.3SF Muna {cookies/bananas/∅}

'Saed ate more cookies than Muna ate (cookies/bananas).'

b. Comparison of quantity (embedded)

saʕed ʔakal baskut ʔaktar mi-ma bɪħku (innu) ʔaklat muna

Saed ate.3SM cookies more from-that said.3PL (that) ate.3SF muna

{*baskut/moz/*∅}

{*cookies/bananas}.

' Saed ate more cookes than they said (that) Muna ate (cookies/bananas).'

(380) McNabb and Kennedy (2011):6

a. Comparison of quality (attributive, non-embedded)

samer iʃtara sayara ʔakbar mi-ma iʃtarat nuha (*sayara kbiira/*fan

Samer bought.3SM car bigger from-that bought.3SF Nuha (*car.F big.F/*van.M

kbiir)

big.M)

'Samer bought a bigger car than Nuha bought (*big) (*car/van).'

b. Comparison of quality (attributive, embedded)

*samer iʃtara sayara ʔakbar mi-ma bɪħku (innu) iʃtarat nuha
Samer bought.3SM car bigger from-that said.3PL (that) bought.3SF Nuha
(*sayara kbiira/*fan kbiir)
(car.F big./van.M big.M)
'Samer bought a bigger car than they said (that) Nuha bought (*big) (*car/van).'

c. Comparison of quality (predicative, non-embedded)

musa kan ʔTwal mi-ma daud kan (*Tawil)
Musa was.3SM taller from-that Daud was.3SM (*tall.SM)
'Musa was taller than Daud was (*tall).'

d. Comparison of quality (predicative, embedded)

musa kan ʔTwal mi-ma bɪħku (innu) daud kan (*Tawil)
Musa was.3SM taller from-that said.3PL (that) Daud was.3SM (*tall.SM)
'Musa was taller than they said (that) Daud was (*tall).'

McNabb and Kennedy analyse this difference between cardinality and degree comparatives as a difference in the underlying behaviour of the two types of adjectives in the syntax. Citing evidence from degree questions in Palestinian Arabic, which are possible for cardinality but not degree adjectives, the authors propose that cardinality adjectives move outside of NP, degree adjectives stay within NP and therefore must be deleted.

In this section, I have shown that, while cardinality and degree comparison show major similarities in a number of the world's languages, there does seem to be evidence that there are underlying differences between the syntax and semantics of *many* and other gradable adjectives in a number of languages as well. This possible distinction is important to keep in mind, and I will return to it in the experimental discussion, Section 6.6.4.

6.5 The Degree Complexity Hypothesis

In this section, I will propose that in addition to the potential semantic distinction proposed by Hackl (2001a), there are reasons to think that cardinality and degree comparatives might not incur the same level of processing complexity that go beyond selectional restrictions or 'lower level' factors, for example a higher degree if lexical frequency of *more* or *fewer* with respect to other comparative adjectives. In Section 6.2.2, I presented evidence from the literature showing that mental representations of plurals are typically vague and undifferentiated, unless there is explicit individuating information, for example introducing a set with a conjoined phrase or ascribing properties to individual set members (e.g., Patson and Warren, 2011). Operations that require access to individual members of a set were shown to be costly (e.g., the conjunction cost) or dispreferred (e.g., interpreting a verb like *wrestled* as reciprocal). These findings about the representation of sets during language processing make a prediction about the processing of cardinality and degree comparatives like (381) and (382), respectively.

(381) John lifted more boxes than Bill lifted, but they both worked hard.

(382) John lifted heavier boxes than Bill lifted, but they both worked hard.

In order to comprehend a cardinality comparative like (392), one must have a (rough) representation of the sizes of the two sets to be compared, but not any properties of individual set members. The reader or listener can therefore maintain an undifferentiated representation of the set that appears to be the mind's default for unmodified plurals, and proceed in making the required ordering with an approximate estimate of the number of members of a set.[14] The cardinality, or size, of a set is likely to be a salient property of any set that is part of a discourse or other mental representation, and as such may be something that comprehenders generate relatively cost-free, as compared to properties of individual set members.[15] If this is true, then cardinality comparison can be thought of as a one-step process of ordering values of cardinality that are available essentially cost-free.

By contrast, the operation required in degree comparison of pluralities is arguably more complex. While the LF-semantics of (381) and (382) can be spelled out similarly, as shown in (383) and (384). Each of these representations contains the assertion a relationship between maximal degrees,

[14]It could be the case that the precision required in order to make a cardinality comparison has an effect on comprehension complexity. For example, if counting of set entities is required in order to make a close judgment in verifying the meaning of a cardinality comparative, processing complexity may be higher than it would be for a comparison where a more approximate representation of the cardinalities of sets is adequate.

[15]Some properties of individual set members may be more costly to add to the representation than others, depending on properties of the plural noun and other lexical content of the sentence context. For instance, it might be easier to assign each member of a set described by *the lightbulbs* a degree of *brightness*, which is a property generally associated with lightbulbs, than a degree of *expensiveness*, which is a property that each lightbulb has, but may not be part of the semantic associations immediately activated by the word lightbulb.

of cardinality or of heaviness. For the cardinality comparative, this representation may even be more complex than is required to comprehend (381), but for now I will suppose that the cardinality comparison does in fact require degree variables in its LF. If it is correct to assume that the cardinality of a set is a part of its mental representation and can be accessed 'for free', then it should be relatively easy to compute the meaning shown in (381). The degree comparative (382) also asserts a relationship between two degrees, but what is less clear is *how* these degrees are obtained from the representations of the set of boxes that John lifted and the set of boxes that Bill lifted.

(383) max d(John lifted d-many boxes) > max d'(Bill lifted d'-many boxes)

(384) max d(John lifted d-heavy boxes) > max d'(Bill lifted d'-heavy boxes).

Knowing what operations are involved in calculating the degrees to be compared in a sentence like (382) requires knowing the truth values of the sentence, which are less clear than the truth values for the corresponding cardinality comparative. As described above, at least two classes of possibilities that have been put forth in the literature for processes by which comprehenders determine whether a comparison between sets in terms of an adjectival scale is true or false, and therefore at least two possible sets of truth values for these sentences. The evidence from Scontras et al. (2012) suggests that a mean value on the relevant scale for the members of a plurality is what is used in comparing that plurality with others along that scale. Scontras et al. (2012) therefore argue for the use of the mean of values[16] on a scale among a set as the relevant values in a comparison (shown in (385) over other possible strategies. These other possibilities, discussed by Scha and Stallard (1988); Schwarzschild (1996) and Matushansky and Ruys (2006), involve pairwise comparison between set members to determine whether sentences like (386) are true or false. These pairwise strategies give rise to different truth conditions for sentences like (386) than the mean-degree strategy. Below, I will describe several of the meanings that have been suggested.

(385) Mean condition:

For sets A, B, adjective R and measure function γ associated with R,
A is R-er than B iff $\dfrac{\Sigma\gamma(a{\in}A)}{|A|} > \dfrac{\Sigma\gamma(b{\in}B)}{|B|}$

[16]The model used by Scontras et al. is probablilistic, but I will use a catergorical model here as a shorthand.

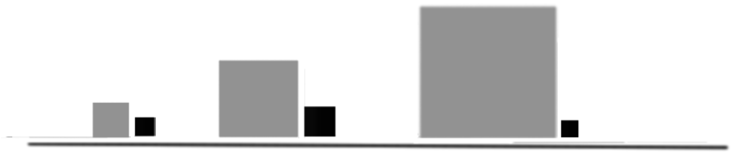

Figure 6.1. Grey and black boxes: 1.

(386) Scha and Stallard (1988):

The frigates are faster than the carriers.

Matushansky and Ruys (2006) take up three possible interpretations of sentences like (386) in turn: the universal-universal condition, the universal-existential condition, and finally the bijective condition. The universal-universal condition (Scha and Stallard, 1988) requires that in order for a sentence like (388) to be judged as true, each member of the set of grey boxes would have to be larger than any member of the set of black boxes. This condition is shown in (387).

(387) Universal-universal condition:

For sets A, B, adjective R and measure function γ associated with R,

A is R-er than B iff $\forall\, a \in A$, for all $b \in B$, $\gamma(a) > \gamma(b)$.

If the space of boxes in question is as in Figure 6.1, then sentence (388) would be judged true according to the universal-universal condition because each grey box is larger than any of the black boxes. However, with respect to the displays in Figures 6.2, 6.3 and 6.4, example (388) would be false according to the universal-universal condition, because not all of the grey boxes are larger than each one of the black boxes.

(388) The grey boxes are larger than the black boxes.

A second way of calculating truth conditions for (388) would be to require that the largest grey box be larger than any of the black boxes in order for the sentence to be true. Under this condition, (388) would be true with respect to Figures 6.1-6.3, but not Figure 6.4. This condition is similar to the universal-existential condition (although Scha and Stallard (1988) discuss partitions of sets, which is beyond the needs of this discussion, and is defined in (389). The last possible condition

Figure 6.2. Grey and black boxes: 2.

Figure 6.3. Grey and black boxes: 3.

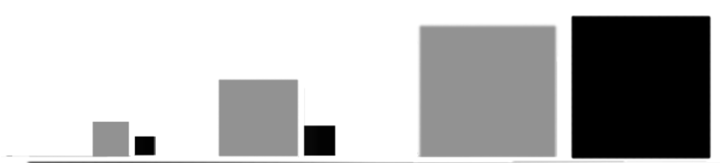

Figure 6.4. Grey and black boxes: 4.

discussed by Matushansky and Ruys (2006) is a bijective condition (390), under which (388) would be judged true if and only if it is possible to form a bijection between individual grey boxes and black boxes such that the grey box in the pair is larger than the black box. With respect to the bijective condition, (388) would be true of Figure 6.1 and 6.2, but false of Figures 6.3 and 6.4, because neither of those displays has a larger to smaller pairing for grey and black boxes.

(389) Universal-existential condition:

For sets A, B, adjective R and measure function γ associated with R,

A is R-er than B iff $\exists\, a \in A, \forall\, b \in B, \gamma(a) > \gamma(b)$.

(390) Bijective condition:

For sets A, B, adjective R and measure function γ associated with R,

A is R-er than B iff $\exists$ a bijection $f : A \to B$ such that for all $a \in A$, $\gamma(a) > f(\gamma(a))$.

Each of the pairwise comparison strategies gives a different set of truth values than a mean-calculating strategy, which would predict *true* in Figures 6.1, 6.2 and 6.4 but would be difficult to judge in the case of Figure 6.3, where the mean size of each colour of boxes would be quite similar.

While the results presented by Scontras et al. (2012) clearly show that the mean value of the members of a set along a scale is used in computing whether a comparative statement is true or false, it is possible that the mean value is not the only strategy that can be used. The idea that multiple verification strategies can be used in different circumstances is present in Lidz et al. (2011), who show that the Approximate Number System is used for short presentations of visual arrays, but admit that a counting strategy might be used if subjects had ample time to make a comparison. In the case of comparing sets, Matushansky and Ruys (2006) give the example (modified slightly here) that if you are making a decision as to which mountain range to choose for a new observatory, what matters is which mountain range has the tallest mountain, not that each mountain in that range be taller than the mountains in the others. In this case, it might be possible for speakers to accept example (391) as true if one of the A mountains is the tallest mountain of either set, and therefore more suitable for the observatory.

(391) The A mountains are taller than the B mountains.

For now, I will move forward assuming that comprehenders may have several strategies available for verifying the truth or falsehood of sentences comparing sets. This discussion leaves open the question of whether we want these different strategies to be encoded in the semantics of comparatives, or whether we want to leave the compositional semantics vague as to how the degrees to be used in the comparison are calculated and move the differences in strategy and therefore in the ultimate truth conditions of the sentence to a higher (for instance, pragmatic) level. Because the strategy used may depend on the context in which the comparative is uttered, including the goals of the conversation (for instance planning an observatory), I am inclined to take the latter approach until more evidence is gathered.

The discussion of the strategies by which truth conditions for plural comparisons like (382) and (386) are computed all leads to the hypothesis that processing degree comparison of sets involves complexity over and above that of comparing cardinalities. This hypothesis, which I call the *Degree Complexity Hypothesis*, is defined in (392). If a mean degree is required to make a comparison, then the degree values of each individual member of a set must be accessed in order to be averaged. This would add an extra, costly step to computing a meaning for (382) and (386). If one of the pairwise strategies is used, the complexity of computing the meaning of (382) and (386) would also be predicted to be complex, as the degree values of individual set members would have to be accessed and either the smallest degree value determined (to be compared to the highest value in the standard of comparison set, for the universal-universal condition) or the highest degree value determined (to be compared to the highest value in the standard of comparison set, for the existential-universal condition). The bijective pairwise strategy has a predicted penalty over and above all of the others, because it would be predicted that all of the degree values in one set be maintained in the representation until the second set is encountered, in order for the bijective relationship to be verified.

(392) *The Degree Complexity Hypothesis*

When comparing pluralities, comparisons that involve properties of individual set members incur more cognitive complexity than comparisons targeting the size (cardinality) of a set.

The alternative to the Degree Complexity Hypothesis would be a hypothesis stating that, outside of the low level factors to do with length and frequency of comparative adjectives, there is no underlying difference in processing complexity between cardinality and degree comparatives, despite the seemingly complex operations required to compute the compared degrees that I have discussed above. Under this view, cardinalities would simply be a special case of a scale of degree comparison, where the the degrees in question are degrees of numerosity rather than, say, degrees of height. Some support for equating cardinality comparison with degree comparison could be drawn from the results of Pietroski et al. (2009) and Lidz et al. (2011). Recall that Pietroski et al. and Lidz et al. found that, with very short presentation times of a visual array, comprehenders' discrimination accuracy for cardinalities in judging sentences with *most* followed Weber's law (that discriminability depends on the ratio between two values), a law that they cite as being important to psychophysical judgments in general.

The Degree Complexity Hypothesis suggests that comparing sets along scales that require access to the degree values of individual members of the sets adds complexity to processing above what is required for cardinality comparison. If the claim that the Logical Forms of both types of comparatives are essentially identical holds, then this complexity could not be claimed to be an increase in difficulty in forming an LF representation of the sentence. The complexity must apply during comprehension past the formation of a licit LF, at the point where the sentence is actually comprehended in relation to nonlinguistic expectations and knowledge and the context of the utterance. The studies by Pietroski et al., Lidz et al. and Hackl suggest that there may be multiple verification strategies available for a single logical form, depending on the nature of the task, although the verification strategy that most is most aligned with the LF of an utterance may be the preferred one. In relation to the Degree Complexity Hypothesis, then, we want to ask: should comprehension above the level of LF should be equated with verification, or is there a level of semantic comprehension between LF and verification? One might think that fully comprehending a sentence could either mean that the reader or listener has generated a set of conditions under which that sentence would be judged true, as modeled formal semantics. However, generating this set of possible scenarios may be too costly and go against the goals of typical comprehension. Garnham (1987) presents evidence that during comprehension, readers (or presumably listeners) perform *instantiation*, a term introduced by Anderson et al. (1976). This instantiation of a sentence is the construction of a mental model of the sentence based on general world knowledge, including prototypical scenarios. For example, although the verb *cooked* in (393) is not maximally specific, a reader of this sentence (from the United Kingdom, where Garnham's studies were conducted) would likely interpret that the housewife in fact *fried* the chips because this is the prototypical way that chips are cooked.

(393) The housewife cooked the chips.

Garnham found that using a verb that was specific to the likely instantiation of sentences like (393), in this case *fried*, was a better cue to recall for the sentence in a memory task than the more general verb that actually formed a part of the sentence. However, subjects often recalled the sentence with the more specific verb, which suggests that they may have been encoding the more specific verb in the linguistic representation of the sentence rather than a post-linguistic instantiation level. A subsequent experiment showed that subjects were more likely to recall the exact target sentence, rather than the one with a more specific verb, in a multiple choice task. Garnham interprets these results as an indication that the cue task targeted a level of interpretation that is not a part of the set of truth values of the sentence, but rather a level of instantiation based on world knowledge.

Section 6.6 will test whether the predictions of the Degree Complexity Hypothesis are borne out in a reading task, outside of explicit verification. Therefore, the Degree Complexity Hypothesis can be thought of as a prediction about complexity at the level of instantiation, rather than at the LF level or verification.

While examining eye movement patterns during reading will determine whether there are differences between cardinality and degree comparatives of sets during on-line sentence processing, outside of an explicit verification task, comparing the two types of comparatives directly presents a problem due to the differences in low-level factors like word length and frequency between cardinality and degree comparatives. Section 6.6.1 presents the experimental design, a priming design, that was adopted in order to avoid length and frequency confounds.

6.6 Experiment 10

6.6.1 Design

This experiment was designed to test the Degree Complexity Hypothesis by looking at eye movements during reading. However, because degree adjectives are generally longer and of lower frequency than adjectives referring to set size (e.g., *more* and *fewer*), a penalty for degree comparatives in reading time as compared to cardinality adjectives would be confounded by these low-level factors, making it impossible to tell if such a difference bore out the predictions of the Degree Complexity Hypothesis. In order to compare degree and cardinality comparison without these confounds, I used a design that rests on the assumption that difficult cognitive operations, such as degree comparison, can be primed.[17] Each item contained two comparatives, as shown in (394). The two comparatives within a sentence either matched or mismatched in their type: cardinality vs. degree comparison. The Degree Complexity Hypothesis, along with the assumption that priming of difficult cognitive operations can take place between the first and second comparative, gives rise to the prediction that going from the simpler cardinality comparative to the more complex degree comparative within an item (condition 394d) should create a larger mismatch than the reverse condition (6.6c).

(394) Sample item set (Analysis regions marked by |)

a. *Cardinality, match:*

John lifted$_{1}$| more boxes$_{2}$| onto the truck$_{3}$| than Steve did,$_{4}$| but fewer crates.$_{5}$| Still, they both worked hard.$_{6}$|

b. *Degree, match:*

John lifted| heavier boxes| onto the truck| than Steve did,| but smaller crates.| Still, they both worked hard.|

c. *Cardinality, mismatch:*

John lifted| heavier boxes| onto the truck| than Steve did,| but fewer crates.| Still, they both worked hard.|

d. *Degree, mismatch:*

John lifted| more boxes| onto the truck| than Steve did,| but smaller crates.| Still, they both worked hard.|

---

[17] One piece of support for the idea that high-level cognition can be influenced by priming comes from Schunn and Dunbar (1996). Schunn and Dunbar found that (sophisticated undergraduate) subjects who solved (or were told the answer to) a biochemistry problem that hinged on the concept of inhibition were more likely to solve an unrelated genetics problem that also involved the concept of inhibition on a subsequent day. This facilitation appeared to occur outside of the realm of explicit analogy - subjects never mentioned the previous task's relevance during verbal reports of their problem solving process - which led the authors to attribute their results to conceptual priming.

The priming design of the experiment allows the results to avoid the length and frequency confounds that come with the two comparative types. However, there is some question as to the exact nature of the priming between the two comparatives. In principle, if we do see mismatch effects for those items where the two comparatives are of different types, this could be due to a lack of parallelism between the two comparatives rather than a lack of priming. I will return to this issue, and whether parallelism and priming can be teased apart here, in the Discussion.

6.6.2 Method

6.6.2.0.5 Materials Twenty-four item sets like those in (394) were constructed. All of the experimental items are given in Appendix A. Each experimental item contained two comparatives. The first comparative had either a quantity (394a,c) or quality (394b,d) adjective. An adverbial phrase separated the associate of the comparative (*more/heavier boxes*) from the standard of comparsion (*than Steve did,*) in all but two items. The second comparative either matched (394a,b) or mismatched (394c,d) in whether the adjective denoted a quantity or quality. For the analyses, the type of the adjective (Comparative Type) and the match or mismatch (Match) between the comparatives will be considered. The experimental items also contained a final continuation sentence in order to eliminate the possibility of wrap-up effects interfering with any effect of the Comparative Type and Match. The experimental items were randomly intermixed with 80 filler items from unrelated experiments. Items appeared on one line of text.

6.6.2.0.6 Procedure Thirty-six UMass undergraduates participated individually in the experiment for psychology course credit. Subjects were tested individually on an Eyelink 1000 Eyetracker (SR Research, Toronto, Canada). Sentences were presented on a CRT monitor such that 3.55 characters subtended one degree of visual angle. Viewing of sentences was binocular, but only movements from the right eye were recorded. After 40% of trials, subjects were given a two-choice comprehension question about the preceding item.

6.6.3 Results

6.6.3.0.7 Comprehension question data

Overall comprehension accuracy was 92.7%. No subjects were excluded from analyses based on poor comprehension data.

6.6.3.0.8 Eye movement data

Means and standard errors for all measures and regions are shown in Table 2.6.2.0.3. Before the data were analyzed, 14% of trials were deleted on the basis of anomalies in the critical analysis region (e.g., blinks or track loss). All measures were analyzed with linear mixed-effects models using the lme4 package (Bates, 2005; Baayen et al., 2008) in R (R Development Core Team, 2012). Models included fixed effects of Adjective Type (either the first or second adjective, depending on the region), Match or mismatch between comparative types, the interaction between these two factors, and Trial Sequence. For Regions 2 and 5, which contained the comparative adjectives, letter length of the comparative adjective and log frequency of the comparative adjective were included in (sometimes secondary) models due to the differences in length and frequency of the comparative adjectives between conditions. Frequencies were gathered from the SUBTLEX$_{US}$ corpus (Brysbaert and New, 2009), a 51-million word corpus of American movie and television subtitles, using the corpus' online interface (http://subtlexus.lexique.org).

6.6.3.0.9 ***First Pass Time*** In First Pass Time, there were effects of interest in Regions 2 and 5, the regions with the first and second comparative adjectives, respectively. The only effect to reach significance in any other region was trial sequence; First Pass Times became significantly faster over the course of the experiment in Regions 1, 4, 5, and 6. All model parameters for all regions are given in Appendix C. In Region 2, the analysis included the Adjective Type (cardinality vs. degree) and the match or mismatch between this adjective and the second comparative adjective. However, the Match factor would have little reason to matter at this point in the sentence, given that the second comparative was several regions downstream. Indeed on Region 2, there was a significant effect of the first Adjective Type (Estimate = 142, SE = 31, t = 4.5) such that degree adjectives had longer First Pass Times than cardinality adjectives. This result is expected given that degree adjectives are typically longer and of lower frequency than the cardinality adjectives (*more* and *fewer*) used in the experiment. When Length and log frequency were included as fixed effects in the LME model, the effect of Adjective Type became nonsignificant (the effect of Log Frequency (per million), however, approached significance. See appendix for full model parameters). No other effects were significant for Region 2. On the second comparative, Region 5, the type of the second adjective and the match between comparatives were included as fixed effects in the analysis. Even though the predicted

	Region 1: Initial region	Region 2: 1st comparative	Region 3: Modifier	Region 4: Than-phrase	Region 5: 2nd comparative	Region 6: Final Region
First Pass Time (ms)						
Cardinality, match	446 (21)	431 (17)	420 (17)	435 (15)	585 (18)	735 (24)
Degree, match	437 (20)	592 (26)	405 (12)	444 (16)	720 (23)	754 (25)
Cardinality, mismatch	420 (19)	544 (24)	406 (14)	446 (14)	582 (14)	744 (15)
Degree, mismatch	408 (18)	421 (17)	397 (14)	475 (15)	774 (27)	745 (27)
Go-Past Time (ms)						
Cardinality, match	446 (21)	554 (22)	441 (19)	494 (19)	653 (28)	1056 (62)
Degree, match	437 (20)	808 (31)	443 (18)	546 (26)	795 (30)	988 (50)
Cardinality, mismatch	420 (19)	811 (31)	466 (22)	528 (26)	638 (27)	1047 (65)
Degree, mismatch	408 (18)	599 (26)	456 (24)	546 (23)	876 (37)	1039 (54)
Total Time (ms)						
Cardinality, match	549 (28)	578 (23)	499 (24)	517 (25)	674 (25)	799 (25)
Degree, match	553 (28)	819 (31)	493 (19)	535 (23)	807 (27)	789 (24)
Cardinality, mismatch	541 (27)	827 (32)	510 (25)	522 (20)	642 (21)	800 (28)
Degree, mismatch	538 (31)	610 (27)	501 (22)	549 (19)	886 (32)	793 (27)
Regressions Out (Prop.)						
Cardinality, match	NA	.17 (.03)	.04 (.01)	.10 (.02)	.06 (.02)	.16 (.03)
Degree, match	NA	.24 (.03)	.05 (.02)	.13 (.02)	.05 (.02)	.15 (.03)
Cardinality, mismatch	NA	.30 (.03)	.08 (.02)	.08 (.02)	.04 (.01)	.17 (.03)
Degree, mismatch	NA	.23 (.03)	.08 (.02)	.11 (.02)	.06 (.02)	.21 (.03)

labeltable1

Table 6.1. Means for eye-movement measures, Experiment 10

Note: NA indicates where a particular measure does not apply to a region (e.g., regressions from the first region of the sentence). Standard errors are presented in parentheses.

result is an interactive one (and therefore it would be differences in reading times between like words that would be compared) and therefore would control for lexical differences between conditions, the length and log frequency per million of the comparative adjective (again from the SUBTLEX$_{US}$ corpus) were included in this and all models for Region 5. One comparative adjective was not attested in the corpus (*snobbier*), and therefore this item was excluded from analyses of this region. In First Pass Time, Length and Log Frequency (per million) were nonsignificant factors. However, we do find that degree adjectives had longer reading times than cardinality adjectives (Estimate = 140, SE = 54, t = 2.6). The predicted interaction, that the mismatch effect would be larger for the degree adjectives than for cardinality adjectives, was numerically present in First Pass Time on Region 5, but the interaction did not reach significance (t = 1.71).

6.6.3.0.10 ***Go-Past Time*** The full pattern of results in Go-Past Time is shown in Figure 6.5. Similar to First Pass Time, Go-Past Time showed effects of Trial Sequence in Regions 1, 2,4 and 6. Region 2, the first comparative, showed a significant effect of Adjective Type (Estimate = 244, SE = 32, t = 7). In Go-Past Time, including length and log frequency in the model did not render the Adjective Type effect nonsignificant. However, log frequency of the comparative adjective was also a significant predictor of Go-Past Time (Estimate = -43.227, SE = 16.565, t = -2.610). Region 5, the second comparative region, showed a main effect of its Adjective Type (Estimate = 226, SE = 73, t = 3.1) and an interaction such that the degree adjective conditions showed a mismatch penalty (simple effect Estimate = 81, SE = 39, t = 2.1), while the cardinality adjective conditions did not differ significantly (Estimate = -21, SE = 34, t = -0.6). As with First-Pass Time and all other measures, on this critical region, the adjective length and log (per million) SUBTLEX$_{US}$ frequencies were included in the model.

6.6.3.0.11 ***Total Time*** The pattern of results for Total Time in each region is shown in Figure 6.6. For Total Time, the effect of trial sequence such that Total Times were shorter over the course of the experiment was significant in all regions. As with the other measures, there were other effects only in Regions 2 and 5. Region 2 showed an effect of the Adjective 1 Type (Estimate = 234, SE = 33, t = 7.1) such that the degree adjectives had longer Total Times than the cardinality adjectives. Similar to Go-Past Time, including log frequency and length in the model showed that length was a significant factor (Estimate = -44.121, SE = 16.277, t = -2.711), but that the Adjective tType was still significant

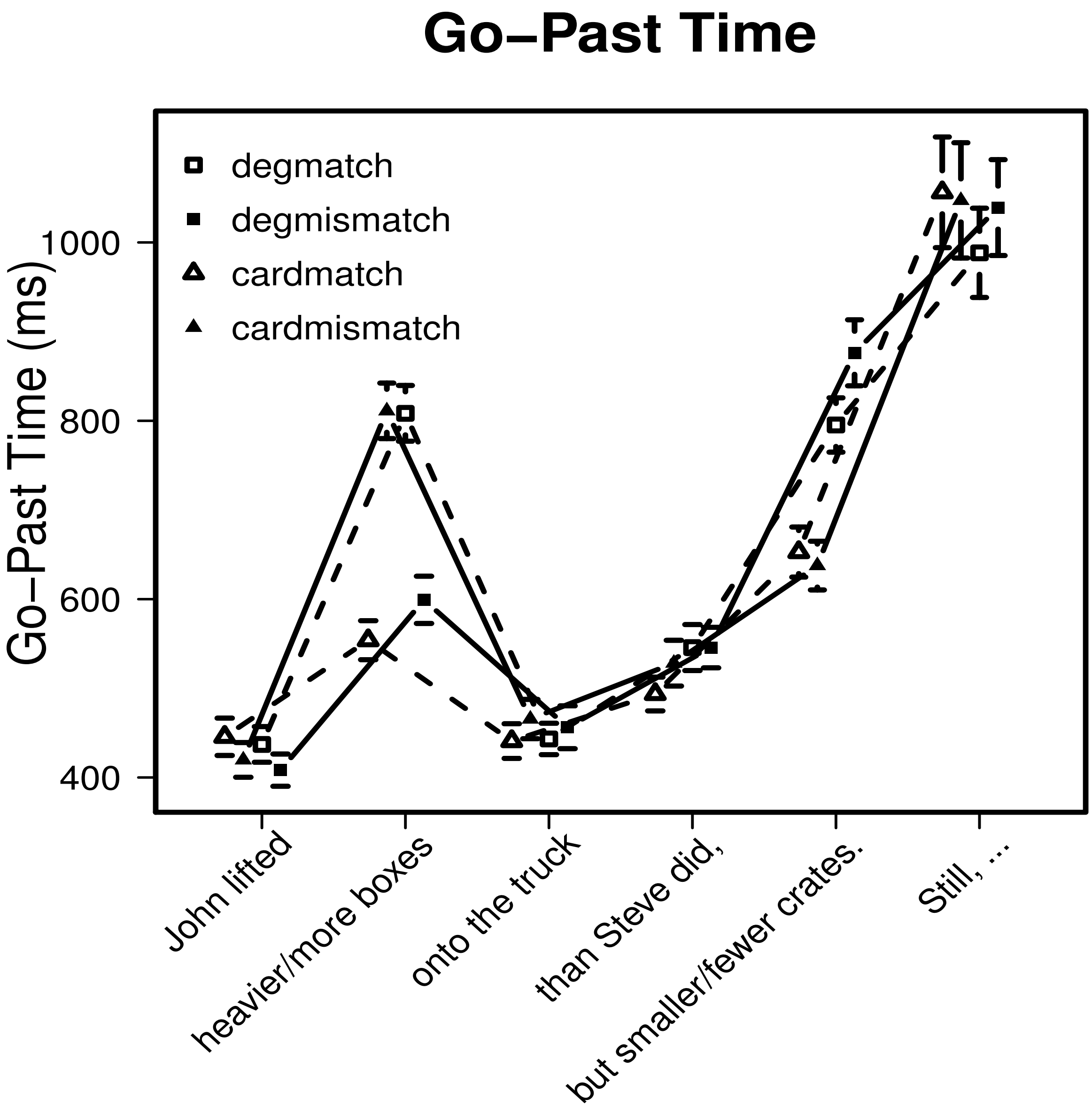

Figure 6.5. Go-past times for all regions, Experiment 10.

also (t = 2.991). On the second comparative, Region 5, there was again an interaction between Adjective 2 Type and Match/Mismatch (Estimate = 130, SE = 49, t = 2.6) as well as significant effect of Adjective 2 Type (Estimate = 178, SE = 61, t = 2.9). Degree adjectives showed a 79ms mismatch penalty (simple effect Estimate = 79, SE = 35, t = 2.2), while there was a nonsignificant 32ms effect in the reverse direction for cardinality adjectives. In addition to the manipulated factors, the effects of Trial Sequence and Log (per million) Frequency of the comparative adjective were significant for this region (see Appendix for complete model parameters). The pattern of results of the critical interaction in both Go-Past Time and Total Time is shown in Figure 6.7.

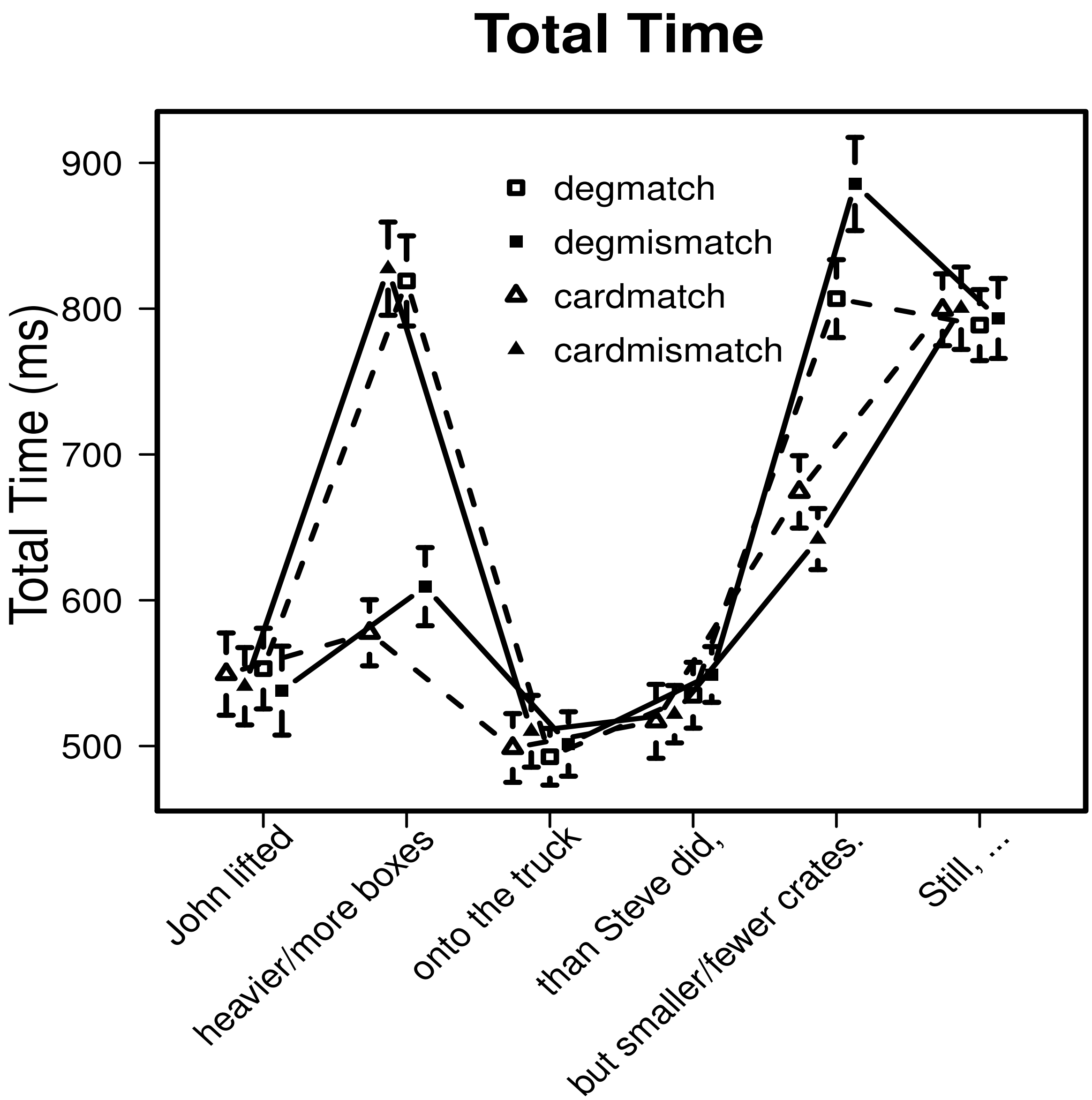

Figure 6.6. Total fixation times for all regions, Experiment 10.

6.6.3.0.12 ***Regressions Out*** The experimental manipulations had few effects on the proportion of Regressions Out of each region of the sentence. On Region 2 (the first region for which Regressions Out is a meaningful measure) there were more regressions for conditions with a degree

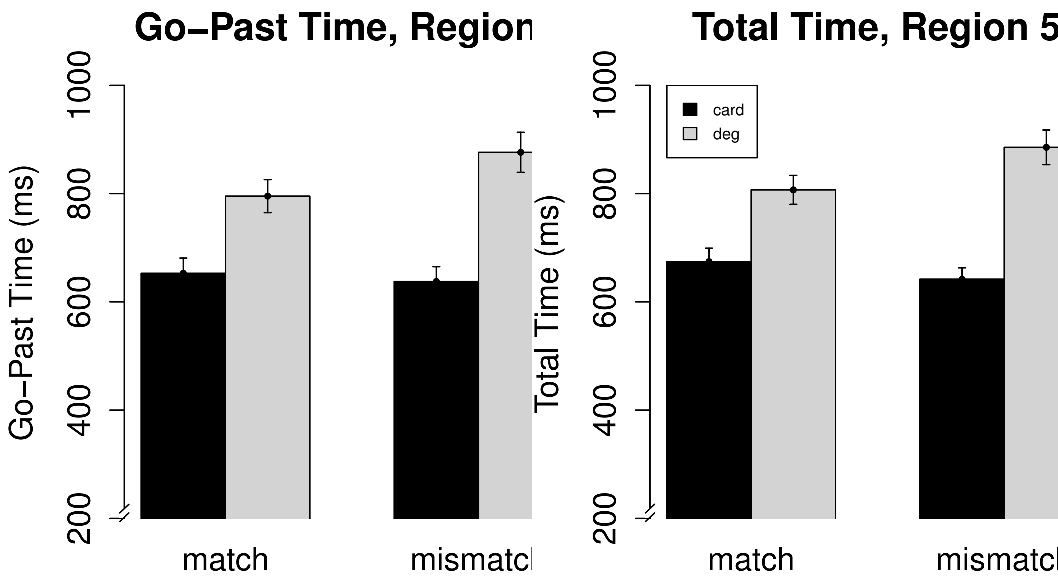

Figure 6.7. Go-Past and Total Times for the critical region (Region 5), Experiment 10. Bars indicate standard errors.

Adjective 1 as opposed to a cardinality Adjective 1 (Estimate = 0.52, 0.21, Z = 2.4, p = 0.0145). This effect was still significant when length and log frequency were added to the model (see Appendix), although length was also a marginally significant factor (Estimate = -0.25, SE = 0.14, z = -1.753, p = .08). In Region 3, there was a significant effect of Match such that mismatching adjectives had approximately 3.5% more regressions than matching conditions on this region. Because this region comes well before the second comparative and is unlikely to be affected by parafoveal preview, this result is unexpected and may be spurious. On the critical second comparative region, Region 5, no effects reached significance.[18] The final region of the sentence showed a significant effect of Trial Sequence such that the odds of making a regression from this region decreased over the course of the experiment.

6.6.3.0.13 ***Choice of connective*** Before proceeding with the discussion of results, it is important to ensure that the effect of Mismatch between the degree adjective conditions is not due to a contrast introduced by the connective *but* between the first and second comparative. In order to determine

[18]The critical interaction had a p-value of .01, but the maximum difference between conditions in Regressions Out for this region was only 2%.

	And		*But*	
	Match	Mismatch	Match	Mismatch
A2 Cardinality	665	623	688	667
A2 Degree	794	916	825	846

Table 6.2. Mean Total Time, Experiment 10 Region 5, by connective.

whether this is a real concern, I separated the items into those that used *but* and those that used the connective *and*, which presumably would not introduced the same contrast between clauses. In contrast to the possibility that the contrast introduced by *but* is generating the mismatch effect, for Total Time on the critical region, the mismatch is largest for the conditions where the connective was *and*, as shown in Table 6.2. The addition of Connective as a factor in the model for Total Time in the critical region showed that this was not a significant factor in Total Time for this region.

6.6.4 Discussion

6.6.4.1 Priming of degree comparison

The central result of the experiment bears out the prediction that the mismatch effect should be greatest for the degree adjective conditions, and therefore provide support for the Degree Complexity Hypothesis. The significant interaction in Go-Past and Total Time on Region 5, the second comparative, shows that there was a mismatch penalty on the second comparatives for degree comparatives, but no such penalty for cardinality comparatives. This result is consistent with the idea that complex cognitive operations, such as degree comparison, can benefit from an immediately previous encounter with that operation - in other words, they can be primed. There are two versions of the priming account that could be put forth. The first type of claim that degree comparison primes not only degree comparison, but also cardinality comparison, while cardinality comparison only primes cardinality comparison. The second type of claim is that degree comparison primes degree comparison, but that cardinality comparison is the simplest type and does not benefit from additional priming. Either of these possibilities could generate the pattern of results found in Go-Past Time and Total Time on the critical region, wherein there is a mismatch effect for degree adjectives but not for cardinality adjectives. In order to decide between these two possibilities, one would need to compare the processing of a cardinality adjective that was not preceded by any type of comparison as compared to a cardinality or degree ‘prime’. The first account would predict that a cardinality comparison not preceded by another comparison would have longer reading times than either of the other two conditions, while the second account would predict that cardinality comparison should be equally facilitated, no matter what prime was used. I leave this test for future research.

In addition to the interaction, the type of the second comparative (in Region 5) was also a significant predictor for First Pass Times, Go-Past Times and Total Times. This effect was present even when length and lexical frequency of the comparative adjective were taken into account. On the first comparative region, Region 2, the comparative type was also a significant predictor. In First-Pass Time, the effect of comparative type in Region 2 was eliminated when length and log frequency were included in the statistical model. However, in Go-Past Time and Total Time, considered to be 'later' measures of processing difficulty, the effect of comparative type was still significant when length and log frequency were included in the model. While these findings were not part of the critical predictions in the experiment, they are indicative that there is extra complexity associated with processing degree comparison that goes beyond low-level factors like length and frequency. Whether this complexity can be attributed to the cognitive operations involved in understanding degree comparison over cardinality comparison remains an open question, as the possibility remains that these effects are due to a lexical factor that I have not included in the analysis.

One potential explanation for the main effect of comparative type falls out of the fact that the comparisons at issue in the experimental materials involve comparing sets. It is possible, as Hackl (2001b) proposes, that *more* necessarily selects for a plurality, whereas other scalar adjectives do not. For instance, the plurality of the NP in the cardinality examples is required; *more* cannot be used with a singular NP, as shown by the comparison between (395a) and (395b). However, degree adjectives (e.g., *smaller*) can be used with either plural or singular NPs, as shown in (395c) and (395d). This difference could mean that the plurality of the NPs modified by degree adjectives is less predicted, or more contentful, than the plurality of NPs modified by *more*, *fewer* or *as many*.

(395) a. John lifted more crates.

b. *John lifted (a) more crate.

c. John lifted smaller crates.

d. John lifted *(a) smaller crate.

However, the degree comparatives in the experimental materials were all bare, without a determiner. Therefore, if there is any difference in the predictiveness of the plurality of the NP following *more* versus the degree adjectives, the difference must be at a deeper level than mere morphological plurality.

6.6.4.2 Attributive and predicative comparatives

The degree comparatives used in this experiment have very complex representations. Degree comparatives like those in (394) and shown in (396a) are so-called *attributive comparatives*, as compared to predicative comparatives like the one shown in (397a). A schematic of the semantic representation of each type of comparative is shown in the (b) versions of the examples.

(396) a. John lifted heavier boxes than Bill lifted..

b. John lifted heavier boxes than λd [~~*d heavy boxes*~~$_i$ Bill lifted t_i]

(397) a. John is taller than Bill (is).

b. John is taller than λd Bill (is) ~~*d tall*~~.

Attributive comparatives show some differences from predicative comparatives. For example, subcomparatives are not possible as attributive comparatives.

(398) Izvorski (1995b):20

a. Bill is more successful than he is talented.

b. *Bill is a more successful actor than he is a talented director.

Kennedy and Merchant (2000) present an analysis of the observation that attributive comparatives show differences from other comparatives in the amount of material that must be elided. For example, the attributive example (399a) is degraded with respect to a version (399b) that has undergone further ellipsis, while there is no intuitive difference in grammaticality between the examples (399c-d).

(399) modified from Kennedy and Merchant (2000), citing Pinkham (1985)

a. *Pico wrote a more interesting novel than Brio wrote a __ play.

b. Pico wrote a more interesting novel than Brio wrote.

c. Pico wrote more novels than Brio wrote __ plays.

d. Pico wrote more novels than Brio wrote.

Kennedy and Merchant's generalization is that for *than*-clauses in attributive comparatives, comparative deletion (in the sense of Bresnan, 1973, inter alia) can only apply if "a constituent that (properly) contains the targeted AP is also eliminiated from the surface representation." In the case of (399a-b), this means deleting the entire DP *d-interesting NP*, and therefore the NPs cannot differ between the matrix clause and the *than*-clauses as they do in (399a).

However, interestingly if the NPs involved are plural, the judgments appear to change. At least to my intuitions, both (400a) and (b) are acceptable sentences.

(400) a. Pico wrote more interesting novels than Brio wrote.

b. Pico wrote more interesting novels than Brio wrote plays.

Because the experimental materials used in the experiment all contain attributive comparatives with determiner-less plural NPs, which appear not to have the same restrictions on deletion or other peculiarities of attributive comparatives with overt determiners, there is no clear reason to think that the results would not generalize to predicative comparatives. However, this is not to say that the structural properties of comparatives should not have any effect on their processing.

Another concern about attributive comparatives such as (401, repeated from above) is that their truth conditions might be even less certain than predicative comparatives with definite determiners, such as (386), repeated as (402). Several native speakers have expressed this intuition.

(401) John lifted heavier boxes than Bill lifted.

(402) The frigates are faster than the carriers.

Part of the complexity of the meaning of (401) may be because the set of boxes that John lifted is not straightforwardly represented in the syntax and semantics of the comparative. In (402) the sets *the frigates* and *the carriers* are explicitly represented in the compositional semantics. However, in order to comprehend (401), the set of boxes that John lifted must be extracted from the semantic representation λd. *John lifted d-heavy boxes*. Inferring this set does seem to be possible, however, as it can be referenced with a pronoun (although with some predicted processing cost).

(403) John lifted heavier boxes than Bill lifted. {They/the boxes} were all full of memorabilia.

What remains to be worked out is how, for example, the meaning of (401) is different from the meaning of (404), which does not compare plural NPs. In a scenario where John and Bill lifted several boxes each, is the sentence true if John lifted one box that was heavier than any of the ones that Bill lifted? This would be an existential-universal reading like those that have been claimed to be available for sentences like (401).

(404) John lifted a heavier box than Bill lifted.

While the above experiment showed that degree comparison of sets involves processing complexity over and above processing cardinalities, this discussion shows that the source of that complexity is still not known in a precise way. Investigating native speaker judgments about the the truth-values of the relevant sentences will help to shed light on this issue.

6.7 Conclusions and Implications for Future Research

The results presented in this chapter show that comparing sets in terms of their degree along an adjectival scale involves complexity above that incurred by comparing cardinalities, and further that this complexity affects reading times of comparatives without an explicit visual array or verification task. These results support the Degree Complexity Hypothesis, that comparisons that require access to properties of individual set members are more complex than comparatives referring merely to the size of a set.

The results of this chapter bring up several broader questions in the processing of cardinality and degree comparison. One open question is whether the complexity associated with degree comparison of sets arises solely from the interaction between comparison and plurality, or whether degree comparison itself introduces complexity in processing. In order to determine the source of the complexity, it will be necessary to conduct further research investigating whether degree comparison of singular entities is more complex than comparison of cardinalities, using for example sentences like (405) and (406).

(405) John lifted more crates than Bill lifted.

(406) John lifted a heavier crate than Bill lifted.

Isolating the difference between cardinality and degree comparison without confounding the issue with plurality is not straightforward. With (405) and (406), there is a confound that (405) involves comparison of sets, while the corresponding degree comparative (406) does not. However, determining whether degrees are complex in terms of processing could add psycholinguistic evidence to the debate over the typological status of degrees presented in Section 6.3.1.

A second question that this chapter leaves open is the division of labour between language processing and a general cognitive mechanism for comparison in comprehending comparatives. Lidz et al. (2011) begin to address this question for verificaton strategies, but no such investigation has been done for on-line sentence processing. One way of teasing apart linguistic from non-linguistic factors in cardinality comparison could be to examine comparatives with *more NPs* as compared to *more numerous NPs* or *a larger number of NPs*.

(407) a. John lifted more crates than Bill lifted.

b. John lifted {more numerous/a larger number of} crates than Bill lifted.

c. John lifted heavier crates than Bill lifted.

Both variants of (407b) use degree comparison form to express cardinality comparison meaning. If these pattern like cardinality comparison and not like degree comparison in processing, then we could conclude that the distinction between cardinalities and degrees is at a level above the linguistic representation of comparatives.

(408) The 2L bottles of soda are heavier than the quarts of milk.

A final question deserving of future investigation is the place of *amounts* in the space of types of comparison. Like cardinalities, comparing amounts refers to the size of a set being compared, for example amounts of beer in (409).

(409) John drank more beer than Bill drank.

(410) John drank cheaper beer than Bill drank.

Cardinalities and amounts, however, are obviously not identical. One way to think about the difference between comparing cardinalities and amounts is that cardinality comparison combines the unit of measure with the entities being measured. For example, *more books* could be said to have the meaning *more book-units of books*. Amounts, on the other hand, leave the unit unspecified unless further information is provided. *More beer* does not necessarily mean *more bottles of beer* or *more kegs of beer*, but rather means some more abstract volume of beer. In this respect, amounts are more like degree comparison. Comparison of degrees, for example *taller men*, also lacks a unit of measure without further specification by a measure phrase.[19]

Investigating these open questions will provide a better understanding of how comparisons are represented, linguistically and in a more general cognitive sense, and how comparisons are computed during language processing.

[19]In fact, with attributive comparatives, it is impossible to add such a measure phrase (e.g., **2cm taller men than women came to the party.*)

CHAPTER 7
CONCLUSIONS

This dissertation examined the processing of comparatives in order to shed light on questions both of processing and of the representation of these constructions. In this concluding chapter, I will summarize the contributions of the dissertation for the theory of the grammar of comparatives, our understanding of the relationship between grammaticality and parsing, and the theory of sentence processing, specifically semantic processing and the integration of different types of information in on-line processing.

7.1 Conclusions for the grammar of comparatives

One of the goals of this dissertation was to evaluate competing grammatical theories of comparatives experimentally. In Chapter 2, the main contribution toward this goal was the motivation for a representation of DP-internal subcomparatives that proposes a phrasal complement to *than*. This type of representation, which treats *more* as a two-place determiner, is not a new proposal (see Keenan, 1987 and Izvorski, 1995a), however Chapter 2 brings new evidence to support the choice of the phrasal representation for DP-internal subcomparatives. If the two-place determiner interpretation of *more* is correct, then this representation should be structurally and semantically simpler than typical comparatives (those with clausal complements to *than*), and therefore it should be the default interpretation of the parser due to economy principles such as Minimal Attachment (Frazier, 1978, 1987b). In cases like (411), which is temporarily ambiguous between a DP-internal sub comparative and typical comparative interpretation, the two-place determiner *more* account predicts a garden path effect at the main verb (in this case *signed*). This garden path would arise because the embedded verb (*encouraged*) would initially be interpreted as a main verb under the two-place determiner interpretation, which at the true main verb *signed* is revealed to be erroneous.

(411) More students than professors encouraged signed the petition.

The data from Experiment 1 in Chapter 2 confirms the existence of the predicted garden path effect, and therefore supports the case that there is a two-place determiner *more* in English, whose associated *than* phrase is an NP and not a reduced clause. There has been a great deal of research on the nature of complements to *than* in English, and whether the complements to *than* are all underlyingly clausal (Lechner, 2001, 2004; Bhatt and Takahashi, 2011a) or a mixture of clausal and phrasal types (Napoli, 1983; Pinkham, 1985; Osborne, 2009). While Chapter 2 provides evidence that there exist some underlyingly phrasal comparatives in English, a remaining question is whether the two-place determiner *more* is limited to the DP-internal subcomparatives discussed in Chapter 2 and again in the discussion of subset comparatives in Chapter 5, or whether phrasal comparatives are a more general phenomenon in English. However, one piece of evidence for the hypothesis that a phrasal complement to *than* is limited to cases of comparisons using *more* and other cardinality comparisons comes from what I call in Chapter 5 Attributive NP-Comparatives (e.g., 412), which compare along adjectival scales. As shown by Lechner (2001), among others, the best hypothesis for the subset requirement in such examples is that there is unspoken content in the *than*-complement, and that this structure contains the associate of comparison (*men*).

(412) Taller men than my father/*mother attended the party.

A consequence of the two-place determiner *more* in English is that a curious pattern or acceptability for comparative clauses, first presented by Osborne (2009), may not need to be modeled in the grammar. In Chapter 2, I presented an account of Osborne (2009)'s pattern of acceptability of comparative clauses in what I call *base* position, immediately adjacent to the *more-NP*. The central claim of the analysis is that the unacceptability of sentences like (413) is due to the parser's inability to revise the representation of the sentence after an initial misanalysis.

(413) *?/# More boys than girls ordered steak ordered salad.

The conclusion of Chapter 2 with respect to Osborne's observations is that there is no need to add additional constraints to our grammatical theory to prevent over-generation of *than*-clauses in base position. Rather, the degraded acceptability of certain *than*-clauses in base position can be attributed to independently motivated principles of sentence processing and reanalysis.

Chapter 5 introduces subset comparatives (e.g., 414-415), a comparative construction that has not been discussed in the literature (although see the “just me" examples in Fults and Phillips, 2004). Unlike typical comparatives, the standard of comparison in a subset comparative (e.g., *eagle/an eagle*) is understood to be a subset of the set described by the associate of comparison (e.g., *eagle*).

(414) More birds than just eagles flew over the conservation area.

(415) More birds than just an eagle flew over the conservation area.

Subset comparatives bear superficial similarities to other types of comparative constructions, such as the DP-internal subcomparatives discussed in Chapter 2 and also Attributive NP-comparatives, such as (412). While I consider the possibility that subset comparatives have either one of these structures, depending on the form of the complement to *than*, I finally introduce a semantic account of the difference between subset comparatives and typical, contrastive comparatives that allows both examples (414) and (415) to have the DP-subcomparative structure.

The semantic analysis in question is to allow two semantic denotations for *more*: one that takes sets of degrees or cardinalities as arguments (used in contrastive comparatives), and one that takes the sets themselves (used for subset comparatives). This analysis has several advantages over a dual structure account. First, if the contrastive *more* is the default interpretation, then this analysis correctly predicts that there is a processing cost associated with subset comparatives. While further research is required into this matter, it seems that the two-*more* account may also be able to account for the Subset Comparative Preupposition, that the main clause predicate is true of the standard of comparison. For example, in (414) it is understood that at least one eagle flew over the conservation area. If the subset comparative *more* carries the implicature that the set represented by the standard of comparison is non-empty, then the Subset Comparative Presupposition follows. Finally, the two-*more* account is more readily extended to comparative clauses that are understood as subsets of the associate of comparison than other candidate accounts. The alternative analyses would all have to rest on elements like *just* to convey the Subset Comparative Presupposition, but elements like *just* cannot be used with comparative clauses (shown in 416).

(416) Linda reported more crimes than (*just) she directly witnessed.

The ability of one lexical item to appear in multiple semantic types is not uncommon, and may not be restricted to *more*. Conjunctions can coordinate items of various semantic types, so long as the types are the same within the coordinated pair. Chapter 5 cites Partee (1986)'s account of the three possible semantic types that Noun/Determiner Phrases may have. The ambiguity of *more* as to the semantic types of the arguments that may be compared could be merely an accidental fact of English, or it could be an example of a systematic extension of one meaning to another. A parallel, but reverse example to the two versions of *more* might be what are called *degree* or *amount relatives* (Carlson, 1977a; Heim, 1987; Grosu and Landman, 1998; Fults, 2003). These structures, such as (417), look like relative clauses but are argued to have an underlying degree semantics. The relative clause is understood to be a set of degrees rather than its typical denotation: a set of individuals. This is the opposite to the case for comparatives, in that typically what is being compared are sets of degrees or cardinalities, but in a special case, subset comparatives, what is compared are sets of individuals.

(417) Heim (1987):

It will take us the rest of our lives to drink the champagne that they spilled that evening.

While Chapter 5 includes a footnote about subset comparatives in German and Dutch, a full typological investigation of these constructions is left for future research. One aspect of subset comparatives that makes the construction so interesting is that it is a comparative construction that is not used to communicate a straightforward comparison between two degrees or quantities. Because of this, one wouldn't be surprised if languages unrelated to English do not exploit comparative syntax to communicate the meanings of sentences like (414), (415) and (416).

7.2 Conclusions for the relationship between grammar and parsing

An issue that Chapter 2 addresses is the relationship between grammar and parsing, and specifically the possible sources of unacceptability in grammar. I argue that the examples that Osborne (2009) marks as ungrammatical are possible sentences according to the grammar, but that they are unacceptable because it is nearly impossible to attain a well-formed representation of these examples during sentence processing. While the idea that unparsable sentences can be disallowed from the grammar is not new (see e.g., Chomsky and Miller, 1963; Frazier, 1985), there is still work to do in determining just how difficult a reanalysis process must be before a sentence gives the impression of ungrammaticality. Recent studies have shown that reader/listeners can form meaningful representations from linguistic input that is not strictly grammatical (Arregui et al., 2006; Grant et al., 2012), although perhaps at a cost in terms of processing difficulty. The results presented in Chapter 2 show the other side of the coin - that readers or listeners may not be able to form meaningful representations of some sentences that are, in fact, possible sentences according to the grammar of the language. Here I have used the term unacceptable for sentences that are ruled out by parsing, but a remaining question is whether a sentence can in fact be considered *ungrammatical* by virtue of its unparsable status. Other proposals have been made for ungrammaticality due to factors outside of syntax, for example Gajewski (2002) argues that syntactically well-formed sentences can be ungrammatical if their Logical Form creates a structural tautology.

In Chapter 4, I propose that the best account of the subject gap penalty in comparative clauses thus far is that these constructions contain a subject island violation, albeit one that is not apparent from the word order in the sentence. This conclusion makes a different claim about the relationship between grammaticality and parsing than is made in the previous chapters. While subject gaps in comparative clauses may be degraded in naturalness ratings and show slow processing times as compared to object gaps, they are not intuitively "ungrammatical." However, if the subject island violation account is correct, then these examples *do* have a grammatical violation.

While the early investigations of the relationship between grammar and processing examined constructions that were clearly grammatical while not parsable (such as center embeddings, (Chomsky and Miller, 1963) or reduced relative-clause garden path sentences (Bever, 1970a; Frazier, 1978)), the empirical domains discussed in this dissertation are those in which the judgments are delicate and subtle, and perhaps too much to allow intuitions to decide between theories. When intuitions are not enough to determine the source of the perceived ungrammaticality for an example or group of examples, we need to develop ways of evaluating whether we want a grammatical analysis or one based on sentence processing.

7.3 Filler-gap processing in comparatives

The results of Chapters 2-4 invite the question of what the process is by which gaps in comparative clauses are filled. Are the gaps left by Comparative Deletion filled using an active filler search, like other gaps left by movement, or by a bottom-up process? The penalty for subject gaps initially argues against treating the processing of Comparative Deletion as an active filler in search of a gap site, because such an account would predict an advantage and not a penalty for subject gaps in comparative clauses. However, it could still be the case that gaps in comparative clauses are filled by an active filler process, but that subject position in a comparative clause is not treated as a potential gap site due to the subject island violation. Previous research has shown that filler-gap processing is sensitive to islands (e.g. Phillips, 2006). Whether real-time sentence processing might be sensitive to the potential subject island violation comparative clauses remains to be determined. Research planned for the future will seek to establish the processing profile of filler-gap processes involving degrees, for instance those involving *'how many'*-questions (or more generally '*how Adj*'-questions). Comparing typical filler-gap constructions created by *wh*-movement (e.g., 418a) to *how-many* questions (e.g., 418b) will be useful in determining how filler-gap relationships involving degrees are processed in general before turning to gaps in comparative clauses left by Comparative Deletion or Subdeletion. Based on the existing literature, we would expect a filled-gap effect in (418a) because there is a potential gap site following *crash* that could potentially be filled by *which car*. In (418b) there is a similar potential for a filled-gap effect following *crash*, but in this case the filler contains a degree. Testing whether the filled-gap effects are similar for these two constructions would give insight into the effect of the presence of degrees on filler-gap relationships.

(418) a. Which car did Sarah crash the shopping carts into __ ?

b. How many cars did Sarah crash the shopping cars into __?

This line of inquiry, however, has certain inherent difficulties. One is that *how many*-questions often contain quantifier scope ambiguities. Villalta (2003) examined the processing of *how many*-questions in context in English and French. For example, Villalta had participants read contexts followed by question targets as shown in (419), and choose an answer to the question that indicated which quantifier scope relationship had been interpreted (e.g., *2* or *6* in response to example 419).

(419) Villalta (2003): 2-3

In the music department, three trumpet students had to pass an exam last week. Every student had to play six pieces. The only requirement they had was that among these there were two pieces that everybody had to play: 'Round Midnight' and 'The Days of Wine and

Roses.' For the rest, the students were free to choose what they preferred.

How many pieces did every student have to play at the exam? (emphasis mine)

For both English and French, with contexts that allowed either scope interpretation, readers chose the inverse-scope reading (corresponding to *six pieces* for 419) more often than the surface scope interpretation. However, the interpretation depended on the preceding context, and specifically which sets were made salient by the preceding context. With a context favouring the surface scope interpretation, the preference for inverse scope was eliminated. Villalta's interpretation of these results is that ambiguity with respect to the set at issue in a *how many* question can cause a delay in the assignment of scope, and therefore in the integration of the moved *how many*-phrase into the semantic interpretation of the sentence. Any further experimentation on *how many* questions as a means of testing degree filler-gap processing will have to take these facts into account.

In addition to the filler-gap relationships in cases of comparative deletion, we might also want to determine how the position of the degree variable is determined in cases of comparative subdeletion. Pursuing these lines of research will provide insight into the parsing of comparative clauses, and what might distinguish filler-gap relationships containing degrees from other types of filler-gap relationships.

7.4 Conclusions for the representation of semantic types

A question that arose in Chapter 6 is whether it is the comparison of pluralities along degree scales that is complex, or whether it is comparisons of degrees themselves that introduce complexity. Whether representing degrees is difficult in language processing is an unanswered question. In Chapter 6 I presented the arguments that others have made in favour of degree parameters in language, and that some languages may not represent degrees as a semantic type at all (Beck et al., 2009; Bochnak, 2011). Whether the typological rarity of degrees (as compared to other semantic types, which are assumed to exist in all languages) is related to the difficulty/complexity of their representations is another open question. Future cross-linguistic research in the processing of comparatives and other degree constructions may be able to provide insight into these questions.

7.5 Conclusions for semantic processing

Chapters 5 and 6 examine questions of semantic processing in comparatives. The issues introduced in these chapters have implications for semantic processing in general, beyond the domain of comparatives. In Chapter 5, a preference for disjoint sets was shown for the processing of comparatives, causing a penalty for comparatives involving sets that could not, based on conceptual or world knowledge, be understood to be disjoint. As mentioned in the conclusions of that chapter, it remains to be determined whether the preference for contrast is limited to sets involved in comparatives, or whether the preference extends to other linguistic contexts as well.

The results of Chapter 6 show that even in the absence of a context that would allow for verification of the meaning of a comparative, there are differences in processing complexity associated with how detailed the instantiated representations of a sentence being built incrementally must be. The experiment presented in this chapter showed that there was increased processing complexity for comparisons of pluralities along a degree scale, which require representation of properties of set members in order to compute the required ordered relationship. By contrast, comparing cardinalities involves representation of the set members in order to determine the size of a set, but no properties of these set members must be represented. In this way, the conclusions for the processing of sets in comparatives support a grammar that contains degree semantics. Independent evidence for the default, undifferentiated representation of plurals comes from studies by Patson and Ferreira (2009) and Patson and Warren (2011) showed that there is limited representation of individual members of plural sets introduced by a simple definite DP, e.g., *the lifeguards*. Instead, these sets are represented as undifferentiated. However, when plurals were introduced with a conjunction, especially when individual set members were targeted by modifiers, then the representations of the individual set members were easier to access (e.g., as participants of reciprocal verbs).

7.6 What type of information takes primacy in processing?

A central issue in Chapter 5 is that of whether the processing of comparatives is driven by bottom-up (input-driven) factors, such as the identity of the words being read, or top-down (knowledge-driven) expectations about the structure and compositional semantics of the material being processed. In the case of subset comparatives, the question was whether a subset relationship that is a part of our lexical/conceptual knowledge (for instance that eagles are birds) would immediately factor in to the processing of comparatives once it is encountered, or whether the expectation for a contrastive comparative would cause a delay in the integration of this information into the current sentence interpretation. This lexical/conceptual category knowledge is a particular type of knowledge about the world. The integration of world knowledge in sentence processing is a topic that has been debated in the psycholinguistic literature (see McRae and Matsuki, 2009 for a review). By *world knowledge*, researchers tend to mean the knowledge that comes from our experiences in the world and typical events and situations, rather than something like cloze predictability (although the two must, of course, be related)[1] Some tests for the timecourse of integration of world knowledge have targeted the plausible objects of verbs (e.g. Altmann and Kamide, 1999) or of instrument-verb pairs (Rayner et al., 2004; Warren and McConnell, 2007; Matsuki et al., 2011). For example, Rayner et al. (2004) used conditions where an object was plausible given the instrument and verb previously mentioned in the sentence (e.g., *the large carrots* following used a knife to chop in 420a), implausible given the instrument and verb (420b) or anomalous (420c).

(420) Rayner et al. (2004): 4

a. John used a knife to chop the large carrots for dinner.

b. John used an axe to chop the large carrots for dinner.

c. John used a pump to inflate the large carrots for dinner.

For this type of world knowledge plausibility manipulation, the results regarding the time course of world knowledge integration have been mixed. While some results have indicated that world knowledge is a driving factor in sentence processing, for example increases in anticipatory eye movements to plausible objects of verbs in visual-world paradigm experiments (e.g., Altmann and Kamide, 1999). In reading time, the effects of plausibility manipulations have not all been immediate. While some studies of eye movements during reading have found plausibility effects on early measures on the critical word (Staub et al., 2007; Matsuki et al., 2011), others have found delayed effects for plausibility violations as opposed to clear anomalies (Rayner et al., 2004; Warren and McConnell, 2007).

[1]The cloze task is a method for collecting data about the predictability of words in context. Normally such a task involves presenting participants with a written sentence fragment and asking them to fill in the word that should come next in the sentence (instructions for individual tasks vary).

Rather than using a plausibility manipulation, Hagoort et al. (2004) studied Event-Related Potentials to violations of real-world knowledge that were not implausible, but false given common knowledge. They tested conditions like those in (421), which were either true (the Dutch trains are commonly known to be *yellow*), plausible but false (*white*), or anomalous (*sour*). Hagoort et al. found that the false items elicited an N400 effect at the critical word that was highly similar (in amplitude, latency and distribution) to that found for the anomalous conditions, suggesting that world knowledge played an immediate role in processing.[2]

(421) Hagoort et al. (2004)

The Dutch trains are *yellow/white/sour...*

The results of Experiment 7 in Chapter 5 indicate that in processing comparatives, the top-down expectation for contrast between the two sets under comparison drives processing, rather than bottom-up lexical/conceptual information. In the absence of clear disambiguation toward a subset comparative (e.g., the presence of *just*), the cost associated with processing a subset comparative only appeared after the critical region had been read. Even when *just* was present in Experiment 8, the critical effects occurred in Go-Past Time and proportion of Regressions Out, which are relatively late measures of processing difficulty in eyetracking. Several questions remain regarding the integration of conceptual subset information during the processing of comparatives. First one might wonder whether category subset relationships would show similarly delayed integration in structures other than comparatives, or whether the top-down expectation for contrast in comparatives is particularly strong. One might also wonder whether the (proto-)typicality of a subset to its larger category would affect the time course of integration of subset information in processing comparatives. For example, there is a chance that, upon encountering an atypical subset-superset pair (e.g., *more birds than penguins...*) readers would force a contrastive interpretation on the sets rather than revising their representation toward a subset comparative interpretation.

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[2]In the particular case described by Hagoort et al. (2004), it is difficult to tease apart effects of world knowledge from lexical association. Such distinctions are important, but often cannot be isolated in the generation of experimental materials.

7.7 Conclusions

The research presented in this dissertation addresses a number of questions in linguistics and psycholinguistics through the lens of comparative constructions. These issues include the way we, as linguists, understand the perception of (non) well-formedness and its relationship to grammar and processing, and the finer layers of acceptability that exist between those examples that are patently ungrammatical and those that are completely acceptable. Like the syntactic and semantic theory of comparatives, the processing of comparatives is complex and multifaceted, bringing together many different sources of information in the formation of one representation. This work forms a part of the larger issue of how semantic processing takes place, and I believe that studying the processing of comparatives provides insight into how semantic representations in general are computed during language comprehension.

APPENDIX A

APPENDIX OF EXPERIMENTAL MATERIALS

Experimental materials, Chapter 2

Experiment 1

1. a) Fewer players than fans admired were inducted into the hall of fame.
   b) Fewer players than Fran admired were inducted into the hall of fame.
   c) The players that fans admired were inducted into the hall of fame.
   d) The players that Fran admired were inducted into the hall of fame.

2. a) Fewer assistants than managers encouraged applied for the promotion.
   b) Fewer assistants than Mr. Hall encouraged applied for the promotion.
   c) The assistants that managers encouraged applied for the promotion.
   d) The assistants that Mr. Hall encouraged applied for the promotion.

3. a) Fewer electricians than carpenters trusted knew how to complete the re-wiring
   b) Fewer electricians than Clarabelle trusted knew how to complete the re-wiring.
   c) The electricians that carpenters trusted knew how to complete the re-wiring.
   d) The electricians that Clarabelle trusted knew how to complete the re-wiring.

4. a) Fewer girls than boys invited went to the party on Friday.
   b) Fewer girls than Burt invited went to the party on Friday.
   c) The girls that boys invited went to the party on Friday.
   d) The girls that Burt invited went to the party on Friday.

5. a) More whales than sharks hunted left for safer waters.
   b) More whales than Steven hunted left for safer waters.
   c) The whales that sharks hunted left for safer waters.
   d) The whales that Steven hunted left for safer waters.

6. a) More waitresses than chefs reprimanded disappointed their customers.
   b) More waitresses than Chuck reprimanded disappointed their customers.
   c) The waitresses that chefs reprimanded disappointed their customers.
   d) The waitresses that Chuck reprimanded disappointed their customers.

7. a) More nurses than patients thanked cared a great deal about their jobs.
   b) More nurses than Percival thanked cared a great deal about their jobs.

c) The nurses that patients thanked cared a great deal about their jobs.
d) The nurses that Percival thanked cared a great deal about their jobs.

8. a) More receptionists than janitors befriended left their offices very tidy.
b) More receptionists than Jonathan befriended left their offices very tidy.
c) The receptionists that janitors befriended left their offices very tidy.
d) The receptionists that Jonathan befriended left their offices very tidy.

9. a) More wizards than witches envied possessed extraordinary powers.
b) More wizards than Whitney envied possessed extraordinary powers.
c) The wizards that witches envied possessed extraordinary powers.
d) The wizards that Whitney envied possessed extraordinary powers.

10. a) More flies than horses attracted were caught in the barn's fly traps.
b) More flies than Horace attracted were caught in the barn's fly traps.
c) The flies that horses attracted were caught in the barn's fly traps.
d) The flies that Horace attracted were caught in the barn's fly traps.

11. a) More robots than people fixed contained mistakes in their programming.
b) More robots than Portia fixed contained mistakes in their programming.
c) The robots that people fixed contained mistakes in their programming.
d) The robots that Portia fixed contained mistakes in their programming.

12. a) More detectives than judges questioned presented evidence about the case.
b) More detectives than Janice questioned presented evidence about the case.
c) The detectives that judges questioned presented evidence about the case.
d) The detectives that Janice questioned presented evidence about the case.

13. a) Fewer millionnaires than reporters interviewed maintained their wealth for a long time.
b) Fewer millionnaires than Rosemarie interviewed maintained their wealth for a long time.
c) The millionnaires who reporters interviewed maintained their wealth for a long time.
d) The millionnaires who Rosemarie interviewed maintained their wealth for a long time.

14. a) Fewer farmers than tourists asked agreed to pose for a photograph.
b) Fewer farmers than Tatianna asked agreed to pose for a photograph.
c) The farmers who tourists asked agreed to pose for a photograph.
d) The farmers who Tatianna asked agreed to pose for a photograph.

15. a) Fewer doormen than tenants threatened filed a report about the incident.
b) Fewer doormen than Theresa threatened filed a report about the incident.
c) The doormen who tenants threatened filed a report about the incident.
d) The doormen who Theresa threatened filed a report about the incident.

16. a) Fewer lawyers than CEOs consulted gave an opinion about the merger.

b) Fewer lawyers than Cara consulted gave an opinion about the merger.
c) The lawyers who CEOs consulted gave an opinion about the merger.
d) The lawyers who Cara consulted gave an opinion about the merger.

17. a) More firefighters than paramedics helped complained of lung problems.
b) More firefighters than Dr. Smythe helped complained of lung problems.
c) The firefighters who paramedics helped complained of lung problems.
d) The firefighters who Dr. Smythe helped complained of lung problems.

18. a) More actresses than agents complimented gave a good performance.
b) More actresses than Arthur complimented gave a good performance.
c) The actresses who agents complimented gave a good performance.
d) The actresses who Arthur complimented gave a good performance.

19. a) More ballerinas than patrons applauded performed a beautiful encore.
b) More ballerinas than Patrick applauded performed a beautiful encore.
c) The ballerinas who patrons applauded performed a beautiful encore.
d) The ballerinas who Patrick applauded performed a beautiful encore.

20. a) More students than teachers scolded improved their work habits.
b) More students than Mr. King scolded improved their work habits.
c) The students who teachers scolded improved their work habits.
d) The students who Mr. King scolded improved their work habits.

21. a) More children than teenagers teased became self-conscious later on.
b) More children than Thomasina teased became self-conscious later on.
c) The children who teenagers teased became self-conscious later on.
d) The children who Thomasina teased became self-conscious later on.

22. a) More wives than salesmen greeted purchased something at the jewelry store.
b) More wives than Salvador greeted purchased something at the jewelry store.
c) The wives that salesmen greeted purchased something at the jewelry store.
d) The wives that Salvador greeted purchased something at the jewelry store.

23. a) More politicians than comedians insulted got voted out in the last election.
b) More politicians than Christine insulted got voted out in the last election.
c) The politicians who comedians insulted got voted out in the last election.
d) The politicians who Christine insulted got voted out in the last election.

24. a) More tenors than sopranos respected wanted to be the center of attention.
b) More tenors than Scarlett respected wanted to be the center of attention.
c) The tenors that sopranos respected wanted to be the center of attention.
d) The tenors that Scarlett respected wanted to be the center of attention.

Experimental Materials, Chapter 3

Experimental Materials, Experiment 2

1. a) Fewer teachers than I knew wrote me a recommendation letter, but I still finished the application.
   b) Fewer teachers wrote me a recommendation letter than I knew, but I still finished the application.
   c) Fewer teachers than knew me wrote me a recommendation letter, but I still finished the application.
   d) Fewer teachers wrote me a recommendation letter than knew me, but I still finished the application.

2. a) Fewer assistants than we annoyed ended up quitting, but we still had to hire more people.
   b) Fewer assistants ended up quitting than we annoyed, but we still had to hire more people.
   c) Fewer assistants than annoyed us ended up quitting, but we still had to hire more people.
   d) Fewer assistants ended up quitting than annoyed us, but we still had to hire more people.

3. a) Fewer experts than we respected agreed with our opinion, but we went ahead anyway.
   b) Fewer experts agreed with our opinion than we respected, but we went ahead anyway.
   c) Fewer experts than respected us agreed with our opinion, but we went ahead anyway.
   d) Fewer experts agreed with our opinion than respected us, but we went ahead anyway.

4. a) Fewer clients than I called needed more information about their accounts, which was surprising.
   b) Fewer clients needed more information about their accounts than I called, which was surprising.
   c) Fewer clients than called me needed more information about their accounts, which was surprising.
   d) Fewer clients needed more information about their accounts than called me, which was surprising.

5. a) Fewer soldiers than we saluted let us try on their hats, mainly because it was against protocol.
   b) Fewer soldiers let us try on their hats than we saluted, mainly because it was against protocol.
   c) Fewer soldiers than saluted us let us try on their hats, mainly because it was against protocol.
   d) Fewer soldiers let us try on their hats than saluted us, mainly because it was against protocol.

6. a) More friends than we talked to were at the party, according to the pictures on Facebook.
   b) More friends were at the party than we talked to, according to the pictures on Facebook.
   c) More friends than talked to us were at the party, according to the pictures on Facebook.
   d) More friends were at the party than talked to us, according to the pictures on Facebook.

7. a) More colleagues than I consulted criticized my work, which was very discouraging.

b) More colleagues criticized my work than I consulted, which was very discouraging.
c) More colleagues than consulted me criticized my work, which was very discouraging.
d) More colleagues criticized my work than consulted me, which was very discouraging

8. a) More customers than we greeted purchased something at the store, after all Christmas was coming.
b) More customers purchased something at the store than we greeted, after all Christmas was coming.
c) More customers than greeted us purchased something at the store, after all Christmas was coming.
d) More customers purchased something at the store than greeted us, after all Christmas was coming.

9. a) More admirers than I loved thought I was a good dancer, which I found out later on.
b) More admirers thought I was a good dancer than I loved, which I found out later on.
c) More admirers than loved me thought I was a good dancer, which I found out later on.
d) More admirers thought I was a good dancer than loved me, which I found out later on.

10. a) More dogs than we chased ran away with a hamburger, which was unfortunate.
b) More dogs ran away with a hamburger than we chased, which was unfortunate.
c) More dogs than chased us ran away with a hamburger, which was unfortunate.
d) More dogs ran away with a hamburger than chased us, which was unfortunate.

11. a) More mice than we frightened lived under the floorboards, much to our dismay.
b) More mice lived under the floorboards than we frightened, much to our dismay.
c) More mice than frightened us lived under the floorboards, much to our dismay.
d) More mice lived under the floorboards than frightened us, much to our dismay.

12. a) More doctors than I helped were on call at the hospital, as it was a busy night.
b) More doctors were on call at the hospital than I helped, as it was a busy night.
c) More doctors than helped me were on call at the hospital, as it was a busy night.
d) More doctors were on call at the hospital than helped me, as it was a busy night.

13. a) More officers than we spoke to read our testimonies, and they found them useful.
b) More officers read our testimonies than we spoke to, and they found them useful.
c) More officers than spoke to us read our testimonies, and they found them useful.
d) More officers read our testimonies than spoke to us, and they found them useful.

14. a) More magicians than we surprised impressed the guests at the show, and afterward everyone was happy.
b) More magicians impressed the guests at the show than we surprised, and afterward everyone was happy.
c) More magicians than surprised us impressed the guests at the show, and afterward everyone was happy.

d) More magicians impressed the guests at the show than surprised us, and afterward everyone was happy.

15. a) More children than I said goodbye to waved at me, perhaps because they were a little bit shy.
    b) More children waved goodbye than I said goodbye to, perhaps because they were a little bit shy.
    c) More children than said goodbye to me waved at me, perhaps because they were a little bit shy.
    d) More children waved at me than said goodbye to me, perhaps because they were a little bit shy.

16. a) More realtors than we hired appreciated our taste in architecture, or so they said.
    b) More realtors appreciated our taste in architecture than we hired, or so they said.
    c) More realtors than hired us appreciated our taste in architecture, or so they said.
    d) More realtors appreciated our taste in architecture than hired us, or so they said.

17. a) More teammates than I hugged gave me a high five, and then we all went out for ice cream.
    b) More teammates gave me a high five than I hugged, and then we all went out for ice cream.
    c) More teammates than hugged me gave me a high five, and then we all went out for ice cream.
    d) More teammates gave me a high five than hugged me, and then we all went out for ice cream.

18. a) More co-workers than I texted sent me an e-mail, and we were able to arrange the next meeting.
    b) More co-workers sent me an e-mail than I texted, and we were able to arrange the next meeting.
    c) More co-workers than texted me sent me an e-mail, and we were able to arrange the next meeting.
    d) More co-workers sent me an e-mail than texted me, and we were able to arrange the next meeting.

19. a) More teachers than I praised chided me for my tardiness, but I guess I deserved it.
    b) More teachers chided me for my tardiness than I praised, but I guess I deserved it.
    c) More teachers than praised me chided me for my tardiness, but I guess I deserved it.
    d) More teachers chided me for my tardiness than praised me, but I guess I deserved it.

20. a) More saleswomen than I complimented said I need a makeover, but it would have been too expensive.
    b) More saleswomen said I need a makeover than I complimented, but it would have been too expensive.
    c) More saleswomen than complimented me said I need a makeover, but it would have been too expensive.

d) More saleswomen said I need a makeover than complimented me, but it would have been too expensive.

21. a) More authors than I interviewed wrote a review of my book, and the reviews were mostly positive.
    b) More authors wrote a review of my book than I interviewed, and the reviews were mostly positive.
    c) More authors than interviewed me wrote a review of my book, and the reviews were mostly positive.
    d) More authors wrote a review of my book than interviewed me, and the reviews were mostly positive.

22. a) More classmates than we recognized walked right by us, but no one's feelings were hurt.
    b) More classmates walked right by us than we recognized, but no one's feelings were hurt.
    c) More classmates than recognized us walked right by us, but no one's feelings were hurt.
    d) More classmates walked right by us than recognized us, but no one's feelings were hurt.

23. a) More policemen than we insulted threatened to arrest us, but we managed to stay out of jail.
    b) More policemen threatened to arrest us than we insulted, but we managed to stay out of jail.
    c) More policemen than insulted us threatened to arrest us, but we managed to stay out of jail.
    d) More policemen theatened to arrest us than insulted us, but we managed to stay out of jail.

24. a) More receptionists than we bothered helped us with our insurance forms, and we all got things sorted out.
    b) More receptionists helped us with our insurance forms than we bothered, and we all got things sorted out.
    c) More receptionists than bothered us helped us with our insurance forms, and we all got things sorted out.
    d) More receptionists helped us with our insurance forms than bothered us, and we all got things sorted out.

Experimental Materials, Experiment 3

1. a) Fewer teachers than the student knew wrote him a recommendation letter for the scholarship application.
   b) Fewer teachers than knew the student wrote him a recommendation letter for the scholarship application.
   c) The teachers that the student knew wrote him a recommendation letter for the scholarship application.
   d) The teachers that knew the student wrote him a recommendation letter for the scholarship application.

2. a) Fewer assistants than the customers annoyed ended up quitting, and the manager was stressed out.
   b) Fewer assistants than annoyed the customers ended up quitting, and the manager was stressed out.
   c) The assistants that the customers annoyed ended up quitting, and the manager was stressed out.
   d) The assistants that annoyed the customers ended up quitting, and the manager was stressed out.

3. a) Fewer experts than the new C.E.O. respected agreed with his opinion about the business merger.
   b) Fewer experts than respected the new C.E.O. agreed with his opinion about the business merger.
   c) The experts that the new C.E.O. respected agreed with his opinion about the business merger.
   d) The experts that respected the new C.E.O. agreed with his opinion about the business merger.

4. a) Fewer clients than the banker called needed more information about their accounts.
   b) Fewer clients than called the banker needed more information about their accounts.
   c) The clients who the banker called needed more information about their accounts.
   d) The clients who called the banker needed more information about their accounts.

5. a) Fewer soldiers than the children saluted let them try on their hats, mainly because it was against protocol.
   b) Fewer soldiers than saluted the children let them try on their hats, mainly because it was against protocol.
   c) The soldiers who the children saluted let them try on their hats, mainly because it was against protocol.
   d) The soldiers who saluted the children let them try on their hats, mainly because it was against protocol.

6. a) More friends than the shy girl talked to were at the party, according to the pictures on Facebook.
   b) More friends than talked to the shy girl were at the party, according to the pictures on Facebook.
   c) The friends that the shy girl talked to were at the party, according to the pictures on Facebook.
   d) The friends that talked to the shy girl were at the party, according to the pictures on Facebook.

7. a) More colleagues than the journalist consulted criticized his work, which was very discouraging.
   b) More colleagues than consulted the journalist criticized his work, which was very discouraging.

c) The colleagues that the journalist consulted criticized his work, which was very discouraging.

d) The colleagues that consulted the journalist criticized his work, which was very discouraging.

8. a) More customers than the merchant greeted purchased something at the store.
   b) More customers than greeted the merchant purchased something at the store.
   c) The customers that the merchant greeted purchased something at the store.
   d) The customers that greeted the merchant purchased something at the store.

9. a) More spectators than the circus performer made fun of actually enjoyed the performance.
   b) More spectators than made fun of the circus performer actually enjoyed the performance.
   c) The spectators that the circus performer made fun of actually enjoyed the performance.
   d) The spectators that made fun of the circus performer actually enjoyed the performance.

10. a) More dogs than the boy chased ran away with a hamburger at the barbeque.
    b) More dogs than chased the boy ran away with a hamburger at the barbeque.
    c) The dogs that the boy chased ran away with a hamburger at the barbeque.
    d) The dogs that chased the boy ran away with a hamburger at the barbeque.

11. a) More mice than the woman frightened lived under the floorboards of the house.
    b) More mice than frightened the woman lived under the floorboards of the house.
    c) The mice that the woman frightened lived under the floorboards of the house.
    d) The mice that frightened the woman lived under the floorboards of the house.

12. a) More doctors than the nurse helped were on call at the hospital, as it was a busy night.
    b) More doctors than helped the nurse were on call at the hospital, as it was a busy night.
    c) The doctors that the nurse helped were on call at the hospital, as it was a busy night.
    d) The doctors that helped the nurse were on call at the hospital, as it was a busy night.

13. a) More officers than the witness spoke to read the testimony, and they found it useful.
    b) More officers than spoke to the witness read our testimony, and they found it useful.
    c) The officers that the witness spoke to read the testimony, and they found it useful.
    d) The officers that spoke to the witness read our testimony, and they found it useful.

14. a) More magicians than the rabbit surprised impressed the audience at the show.
    b) More magicians than surprised the rabbit impressed the audience at the show.
    c) The magicians that the rabbit surprised impressed the audience at the show.
    d) The magicians that surprised the rabbit impressed the audience at the show.

15. a) More children than the teacher said goodbye to waved at each other before getting on the school bus.
    b) More children than said goodbye to the teacher waved at each other before getting on the school bus.

c) The children that the teacher said goodbye to waved at each other before getting on the school bus.

d) The children that said goodbye to the teacher waved at each other before getting on the school bus.

16. a) More realtors than the designer hired appreciated her taste in architecture, or so they said.

b) More realtors than hired the designer appreciated her taste in architecture, or so they said.

c) The realtors who the designer hired appreciated her taste in architecture, or so they said.

d) The realtors who hired the the designer appreciated her taste in architecture, or so they said.

17. a) More teammates than the soccer player hugged gave him a high five after the game.

b) More teammates than hugged the soccer player gave him a high five after the game.

c) The teammates that the soccer player hugged gave him a high five after the game.

d) The teammates that hugged the soccer player gave him a high five after the game.

18. a) More co-workers than the boss texted sent everyone an e-mail, and they were able to arrange the next meeting.

b) More co-workers than texted the boss sent everyone an e-mail, and they were able to arrange the next meeting.

c) The co-workers that the boss texted sent everyone an e-mail, and they were able to arrange the next meeting.

d) The co-workers that texted the boss sent everyone an e-mail, and they were able to arrange the next meeting.

19. a) More instructors than the trainee praised emphasized rules and discipline in the workplace.

b) More instructors than praised the trainee emphasized rules and discipline in the workplace.

c) The instructors who the trainee praised emphasized rules and discipline in the workplace.

d) The instructors who praised the trainee emphasized rules and discipline in the workplace.

20. a) More saleswomen than the shopper complimented ended up having good sales that day.

b) More saleswomen than complimented the shopper ended up having good sales that day.

c) The saleswomen that the shopper complimented ended up having good sales that day.

d) The saleswomen that complimented the shopper ended up having good sales that day.

21. a) More authors than the painter met made the New York Times bestseller list that year.

b) More authors than met the painter made the New York Times bestseller list that year.

c) The authors that the painter met made the New York Times bestseller list that year.

d) The authors that met the painter made the New York Times bestseller list that year.

22. a) More former classmates than the college student recognized often went out for drinks at the ABC.

b) More former classmates than recognized the college student often went out for drinks at the ABC.

c) The former classmates that the college student recognized often went out for drinks at the ABC.

d) The former classmates that recognized the college student often went out for drinks at the ABC.

23. a) More policemen than the angry teenager insulted threatened to arrest him, but he managed to stay out of jail.

    b) More policemen than insulted the angry teenager threatened to arrest him, but he managed to stay out of jail.

    c) The policemen that the angry teenager insulted threatened to arrest him, but he managed to stay out of jail.

    d) The policemen that insulted the angry teenager threatened to arrest him, but he managed to stay out of jail.

24. a) More receptionists than the accountant bothered ended up helping out with the paperwork.

    b) More receptionists than bothered the accountant ended up helping out with the paperwork.

    c) The receptionists that the accountant bothered ended up helping out with the paperwork.

    d) The receptionists that bothered the accountant ended up helping out with the paperwork.

Experimental Materials, Pilot Experiment 4

1. a) I met more scholars than contacted Susan before the conference.

   b) I met more scholars than Susan contacted before the conference.

2. a) Biden greeted more people than Obama talked to at the town hall meeting.

   b) Biden greeted more people than talked to Obama at the town hall meeting.

3. a) Dave admired more athletes than waved to Sarah.

   b) Dave admired more athletes than Sarah waved to.

4. a) Mrs. Smith inspired more students than Mr. Norton impressed.

   b) Mrs. Smith inspired more students than impressed Mr. Norton.

5. a) Tanya disliked more co-workers than insulted Steven.

   b) Tanya disliked more co-workers than Steven insulted.

6. a) Harry called more buddies than Franck listened to.

   b) Harry called more buddies than listened to Frank.

7. a) The host invited more party guests than liked the guest of honor.

   b) The host invited more party guests than the guest of honor liked.

8. a) The military commended more sailors than the captain praised.

   b) The military commended more sailors than praised the captain.

Experimental Materials, Experiment 5

1. a) The detective interrogated the man he understood the police officer threatened, because it was important to find out the truth.
   b) The detective interrogated the man he understood threatened the police officer, because it was important to find out the truth.
   c) The detective interrogated the man he believed the police officer threatened, because it was important to find out the truth.
   d) The detective interrogated the man he believed threatened the police officer, because it was important to find out the truth.

2. a) The bartender served the guy you sensed Mary likes, but overall it was a quiet night.
   b) The bartender served the guy you sensed likes Mary, but overall it was a quiet night.
   c) The bartender served the guy you confessed Mary likes, but overall it was a quiet night.
   d) The bartender served the guy you confessed likes Mary, but overall it was a quiet night.

3. a) The assistant apologized to the employee he forgot the boss is related to, and it turned out to be a wise move.
   b) The assistant apologized to the employee he forgot is related to the boss, and it turned out to be a wise move.
   c) The assistant apologized to the employee he guessed the boss is related to, and it turned out to be a wise move.
   d) The assistant apologized to the employee he guessed is related to the boss, and it turned out to be a wise move.

4. a) The teacher spoke to the girl she recognizes Robbie copied on the test, and decided what to do about the incident.
   b) The teacher spoke to the girl she recognizes copied Robbie on the test, and decided what to do about the incident.
   c) The teacher spoke to the girl she suspects Robbie copied on the test, and decided what to do about the incident.
   d) The teacher spoke to the girl she suspects copied Robbie on the test, and decided what to do about the incident.

5. a) The professor met with the student he observed Sheila tutor, and stressed how important Chapter 2 of the textbook was.
   b) The professor met with the student he observed tutor Sheila, and stressed how important Chapter 2 of the textbook was.
   c) The professor met with the student he suggested Sheila tutor, and stressed how important Chapter 2 of the textbook was.
   d) The professor met with the student he suggested tutor Sheila, and stressed how important Chapter 2 of the textbook was.

6. a) John saluted the general he found honored the injured soldiers, in order to show respect.
   b) John saluted the general he found the injured soldiers honored, in order to show respect.
   c) John saluted the general he thought honored the injured soldiers, in order to show respect.

d) John saluted the general he thought the injured soldiers honored, in order to show respect.

7. a) The volunteer called the voters she established the candidate would help, because the election race was very competitive.
   b) The volunteer called the voters she established would help the candidate, because the election race was very competitive.
   c) The volunteer called the voters she bet the candidate would help, because the election race was very competitive.
   d) The volunteer called the voters she bet would help the candidate, because the election race was very competitive.

8. a)
   b) George chatted with the former friend he accepted Sarah couldn't forgive, but the conversation was pretty awkward.
   c) George chatted with the former friend he accepted couldn't forgive Sarah, but the conversation was pretty awkward.
   d) George chatted with the former friend he realized Sarah couldn't forgive, but the conversation was pretty awkward.
   e) George chatted with the former friend he realized couldn't forgive Sarah, but the conversation was pretty awkward.

9. a) The newscaster interviewed the politician he revealed Alice bribed, and the scandal became national news.
   b) The newscaster interviewed the politician he revealed bribed Alice, and the scandal became national news.
   c) The newscaster interviewed the politician he reported Alice bribed, and the scandal became national news.
   d) The newscaster interviewed the politician he reported bribed Alice, and the scandal became national news.

10. a) Sally consulted the genius we recalled William beat at chess, because she needed help with a difficult brain-teaser.
    b) Sally consulted the genius we recalled beat William at chess, because she needed help with a difficult brain-teaser.
    c) Sally consulted the genius we doubted William beat at chess, because she needed help with a difficult brain-teaser.
    d) Sally consulted the genius we doubted beat William at chess, because she needed help with a difficult brain-teaser.

11. a) The witness pointed at the defendant you saw the lawyer winked at, and things were very tense in the courtroom.
    b) The witness pointed at the defendant you saw winked at the lawyer, and things were very tense in the courtroom.
    c) The witness pointed at the defendant you swore the lawyer winked at, and things were very tense in the courtroom.

d) The witness pointed at the defendant you swore winked at the lawyer, and things were very tense in the courtroom.

12. a) The security guard turned his attention to the store owner we signaled the robber was running away from, to see what had really happened.
    b) The security guard turned his attention to the store owner we signaled was running away from the robber, to see what had really happened.
    c) The security guard turned his attention to the store owner we decided the robber was running away from, to see what had really happened.
    d) The security guard turned his attention to the store owner we decided was running away from the robber, to see what had really happened.

13. a) The judge revoked the license of the driver I understood Terry hit on Friday, and also imposed a hefty fine.
    b) The judge revoked the license of the driver I understood hit Terry on Friday, and also imposed a hefty fine.
    c) The judge revoked the license of the driver I realized Terry hit on Friday, and also imposed a hefty fine.
    d) The judge revoked the license of the driver I realized hit Terry on Friday, and also imposed a hefty fine.

14. a) The producer wondered about the co-star he sensed the lead actress dated, because he didn't want any conflicts on set.
    b) The producer wondered about the co-star he sensed dated the lead actress, because he didn't want any conflicts on set.
    c) The producer wondered about the co-star he suspected the lead actress dated, because he didn't want any conflicts on set.
    d) The producer wondered about the co-star he suspected dated the lead actress, because he didn't want any conflicts on set.

15. a) We hired the juvenile delinquent we accepted Sarah cared for, because we needed some help with yard work.
    b) We hired the juvenile delinquent we accepted cared for Sarah, because we needed some help with yard work.
    c) We hired the juvenile delinquent we doubted Sarah cared for, because we needed some help with yard work.
    d) We hired the juvenile delinquent we doubted cared for Sarah, because we needed some help with yard work.

16. a) Maria was friends with the swimming student she found the instructor annoyed, but overall the swim class was fun.
    b) Maria was friends with the swimming student she found annoyed the instructor, but overall the swim class was fun.
    c) Maria was friends with the swimming student she bet the instructor annoyed, but overall the swim class was fun.

d) Maria was friends with the swimming student she bet annoyed the instructor, but overall the swim class was fun.

17. a) The investigators questioned the guy they recognized the thief outsmarted, and found out some useful information.

b) The investigators questioned the guy they recognized outsmarted the thief, and found out some useful information.

c) The investigators questioned the guy they confessed the thief outsmarted, and found out some useful information.

d) The investigators questioned the guy they confessed outsmarted the thief, and found out some useful information.

18. a) The school principal met with the superintendent he forgot Henry fired, but the subject didn't come up in conversation.

b) The school principal met with the superintendent he forgot fired Henry, but the subject didn't come up in conversation.

c) The school principal met with the superintendent he thought Henry fired, but the subject didn't come up in conversation.

d) The school principal met with the superintendent he thought fired Henry, but the subject didn't come up in conversation.

19. a) The philanthropist gave money to the hospital he observed Oliver changed for the better, and the money went to good use.

b) The philanthropist gave money to the hospital he observed changed Oliver for the better, and the money went to good use.

c) The philanthropist gave money to the hospital he reported Oliver changed for the better, and the money went to good use.

d) The philanthropist gave money to the hospital he reported changed Oliver for the better, and the money went to good use.

20. a) The professors looked for the colleague they recalled John mentioned yesterday, but were out of luck.

b) The professors looked for the colleague they recalled mentioned John yesterday, but were out of luck.

c) The professors looked for the colleague they swore John mentioned yesterday, but were out of luck.

d) The professors looked for the colleague they swore mentioned John yesterday, but were out of luck.

21. a) We waited backstage for the ballerina you revealed Chris admired, because everyone wanted her autograph.

b) We waited backstage for the ballerina you revealed admired Chris, because everyone wanted her autograph.

c) We waited backstage for the ballerina you suggested Chris admired, because everyone wanted her autograph.

d) We waited backstage for the ballerina you suggested admired Chris, because everyone wanted her autograph.

22. a) Larry asked for information about the guy he saw Claire invited to the dance, because they were all sharing a limousine.
    b) Larry asked for information about the guy he saw invited Claire to the dance, because they were all sharing a limousine.
    c) Larry asked for information about the guy he believed Claire invited to the dance, because they were all sharing a limousine.
    d) Larry asked for information about the guy he believed invited Claire to the dance, because they were all sharing a limousine.

23. a) The deputy turned toward the city councillor he signaled the mayor supported, because they were all talking about an important by-law.
    b) The deputy turned toward the city councillor he signaled supported the mayor, because they were all talking about an important by-law.
    c) The deputy turned toward the city councillor he guessed the mayor supported, because they were all talking about an important by-law.
    d) The deputy turned toward the city councillor he guessed supported the mayor, because they were all talking about an important by-law.

24. a) The corrupt prime minister supported the candidate he established the voters valued, but everyone knew the election wasn't fair.
    b) The corrupt prime minister supported the candidate he established valued the voters, but everyone knew the election wasn't fair.
    c) The corrupt prime minister supported the candidate decided the voters valued, but everyone knew the election wasn't fair.
    d) The corrupt prime minister supported the candidate decided valued the voters, but everyone knew the election wasn't fair.

Experimental Materials, Chapter 4

Materials, Experiment 6

These are the romanized version of the sentences used in the experiment, with glosses. Please contact the author for the versions used in the pilot experiment.

1. a. sai-ga otta yori-mo ookuno zou-ga takai kusa-o tabeteimasita
   rhino-NOM chased YORI-MO many elephant-NOM tall grass-ACC were.eating
   'More elephants than the rhino chased grazed on the tall grass.'

   b. sai-o otta yori-mo ookuno zou-ga takai kusa-o tabeteimasita
   rhino-ACC chased YORI-MO many elephant-NOM tall grass-ACC were.eating
   'More elephants than chased the rhino grazed on the tall grass. '

   c. sai-ga otta ookuno zou-ga takai kusa-o tabeteimasita
   rhino-NOM chased many elephant-NOM tall grass-ACC were.eating
   'Many elephants that the rhino chased grazed on the tall grass.'

d. sai-o otta ookuno zou-ga takai kusa-o tabeteimasita
rhino-ACC chased many elephant-NOM tall grass-ACC were.eating
'Many elephants that chased the rhino grazed on the tall grass.'

2. a. yagiu-ga ketta yori-mo ookuno uma-ga kodomo-nimukete ureshiku
goats-NOM kicked YORI-MO many horses-NOM children-at happily
naita
whinnied
'More horses than the goats kicked whinnied happily at the children.'

b. yagiu-o ketta yori-mo ookuno uma-ga kodomo-nimukete ureshiku
goats-ACC kicked YORI-MO many horses-NOM children-at happily
naita
whinnied
'More horses than kicked the goats whinnied happily at the children.'

c. yagiu-ga ketta ookuno uma-ga kodomo-nimukete ureshiku naita
goats-NOM kicked many horses-NOM children-at happily whinnied
'Many horses that the goat kicked whinnied happily at the children.'

d. yagiu-o ketta ookuno uma-ga kodomo-nimukete ureshiku naita
goats-ACC kicked many horses-NOM children-at happily whinnied
'Many horses that kicked the goat whinnied happily at the children.'

3. a. keikan-ga oshita yori-mo ookuno hannin-ga saibansho-de
policeman-NOM shoved YORI-MO many criminal-NOM courthouse-at
bengoshi-o ketta
lawyer-ACC kicked
'More criminals than the policeman shoved kicked the bailiff at the courthouse.'

b. keikan-o oshita yori-mo ookuno hannin-ga saibansho-de bengoshi-o
policeman-ACC shoved YORI-MO many criminal-NOM courthouse-at lawyer-ACC
ketta
kicked
'More criminals than shoved the policeman kicked the bailiff at the courthouse.'

c. keikan-ga oshita ookuno hannin-ga saibansho-de bengoshi-o ketta
policeman-NOM shoved many criminal-NOM courthouse-at lawyer-ACC kicked
'Many criminals that the policeman shoved kicked the bailiff at the courthouse.'

d. keikan-o oshita ookuno hannin-ga saibansho-de bengoshi-o ketta
policeman-ACC shoved many criminal-NOM courthouse-at lawyer-ACC kicked
'Many criminals that shoved the policeman kicked the bailiff at the courthouse.'

4. a. seinen-ga karakatta yori-mo ookuno kodomo-ga gakkou-de sensei-o
young.boy-NOM teased YORI-MO many child-NOM school-at teacher-ACC
okoraseta
angered
'More children than the teenagers teased angered their teachers at school.'

b. seinen-o karakatta yori-mo ookuno kodomo-ga gakkou-de sensei-o
young.boy-ACC teased YORI-MO many child-NOM school-at teacher-ACC
okoraseta
angered

‘More children than teased the teenagers angered their teachers at school.’

c. seinen-ga karakatta ookuno kodomo-ga gakkou-de sensei-o okoraseta
young.boy-NOM teased many child-NOM school-at teacher-ACC angered
‘Many children that the teenagers teased angered their teachers at school.’

d. seinen-o karakatta ookuno kodomo-ga gakkou-de sensei-o okoraseta
young.boy-ACC teased many child-NOM school-at teacher-ACC angered
‘Many children that teased the teenagers angered their teachers at school.’

5. a. shouboushi-ga sukutta yori-mo ookuno kangoshi-ga gaishou-toreeningu-o uketa
fireman-NOM saved YORI-MO many nurse-NOM trauma-training-ACC took
‘More nurses than the firefighters saved took trauma training.’

b. shouboushi-o sukutta yori-mo ookuno kangoshi-ga gaishou-toreeningu-o uketa
fireman-ACC saved YORI-MO many nurse-NOM trauma-training-ACC took
‘More nurses than saved the firefighters took trauma training.’

c. shouboushi-ga sukutta ookuno kangoshi-ga gaishou-toreeningu-o uketa
fireman-NOM saved many nurse-NOM trauma-training-ACC took
‘Many nurses that the firefighters saved took trauma training.’

d. shouboushi-o sukutta ookuno kangoshi-ga gaishou-toreeningu-o uketa
fireman-ACC saved many nurse-NOM trauma-training-ACC took
‘Many nurses that saved the firefighters took trauma training.’

6. a. myuujishan-ga/o hometa yori-mo ookuno joyuu-ga
musician-NOM/ACC complimented YORI-MO many actress-NOM
yoi-kouen-o-shita
good-performance-ACC-did
‘More actresses than the musicians complimented gave a good performance.’

b. myuujishan-ga/o hometa yori-mo ookuno joyuu-ga
musician-NOM/ACC complimented YORI-MO many actress-NOM
yoi-kouen-o-shita
good-performance-ACC-did
‘More actresses than complimented the musicians gave a good performance.’

c. myuujishan-ga/o hometa ookuno joyuu-ga
musician-NOM/ACC complimented many actress-NOM
yoi-kouen-o-shita
good-performance-ACC-did
‘Many actresses that the musicians complimented gave a good performance.’

d. myuujishan-ga/o hometa ookuno joyuu-ga
musician-NOM/ACC complimented many actress-NOM
yoi-kouen-o-shita
good-performance-ACC-did
‘Many actresses that complimented the musicians gave a good performance.’

7. a. same-ga kougeki-shita yori-mo ookuno ryoushi-ga ookina kuromaguro-o
shark-NOM attacked YORI-MO many fisherman-NOM big bluefin-ACC
tsutta
caught
‘More fishermen than the sharks attacked caught some very large bluefin tuna.’

b. same-o kougeki-shita yori-mo ookuno ryoushi-ga ookina kuromaguro-o
shark-ACC attacked YORI-MO many fisherman-NOM big bluefin-ACC
tsutta
caught

'More fishermen than attacked the sharks caught some very large bluefin tuna.'

c. same-ga kougeki-shita ookuno ryoushi-ga ookina kuromaguro-o tsutta
shark-NOM attacked many fisherman-NOM big bluefin-ACC caught

'Many fishermen that the sharks attacked caught some very large bluefin tuna.'

d. same-o kougeki-shita ookuno ryoushi-ga ookina kuromaguro-o tsutta
shark-ACC attacked many fisherman-NOM big bluefin-ACC caught

'Many fishermen that attacked the sharks caught some very large bluefin tuna.'

8. a. kobito-ga damashita yori-mo ookuno kyojin-ga hashi-kara ochiteshimatta
elf-NOM tricked YORI-MO many giant-NOM bridge-from fell

'More giants than the elves tricked took a terrible fall off the bridge.'

b. kobito-o damashita yori-mo ookuno kyojin-ga hashi-kara ochiteshimatta
elf-ACC tricked YORI-MO many giant-NOM bridge-from fell

'More giants than tricked the elves took a terrible fall off the bridge.'

c. kobito-ga damashita ookuno kyojin-ga hashi-kara ochiteshimatta
elf-NOM tricked many giant-NOM bridge-from fell

'Many giants that the elves tricked took a terrible fall off the bridge.'

d. kobito-o damashita ookuno kyojin-ga hashi-kara ochiteshimatta
elf-ACC tricked many giant-NOM bridge-from fell

'Many giants that tricked the elves took a terrible fall off the bridge.'

9. a. ryoushi-ga mita yori-mo ookuno shinrin-kanshi-in-ga mainichi
hunter-NOM saw YORI-MO many forest-patrol-person-NOM every.day
mori-o patorooru-shita
forest-ACC patrolled

'More rangers than the hunter saw patrolled the park every day.'

b. ryoushi-o mita yori-mo ookuno shinrin-kanshi-in-ga mainichi mori-o
hunter-ACC saw YORI-MO many forest-patrol-person-NOM every.day forest-ACC
patorooru-shita
patrolled

'More rangers than saw the hunter patrolled the park every day.'

c. ryoushi-ga mita ookuno shinrin-kanshi-in-ga mainichi mori-o
hunter-NOM saw many forest-patrol-person-NOM every.day forest-ACC
patorooru-shita
patrolled

'Many rangers that the hunter saw patrolled the park every day.'

d. ryoushi-o mita ookuno shinrin-kanshi-in-ga mainichi mori-o
hunter-ACC saw many forest-patrol-person-NOM every.day forest-ACC
patorooru-shita
patrolled

'Many rangers that saw the hunter patrolled the park every day.'

10. a. seijika-ga hometa yori-mo ookuno katsudouka-ga
politican-NOM praised YORI-MO many activists-NOM
seiken-koudai-shitehoshikatta
government-change-wanted
'More activists than the politicians praised wanted change in the government.'

b. seijika-o hometa yori-mo ookuno katsudouka-ga
politican-ACC praised YORI-MO many activists-NOM
seiken-koudai-shitehoshikatta
government-change-wanted
'More activists than praised the politicians wanted change in the government.'

c. seijika-ga hometa ookuno katsudouka-ga seiken-koudai-shitehoshikatta
politican-NOM praised many activists-NOM government-change-wanted
'Many activists that the politicians praised wanted change in the government.'

d. seijika-o hometa ookuno katsudouka-ga seiken-koudai-shitehoshikatta
politican-ACC praised many activists-NOM government-change-wanted
'Many activists that praised the politicians wanted change in the government.'

11. a. tantei-ga bengo-shita yori-mo ookuno bengoshi-ga
detective-NOM defended YORI-MO many lawyer-NOM
shikaiin-kara wairo-o moratta
city.council.person-from bribe-ACC received
'More employees than the detective defended took bribes from the city councilman.'

b. tantei-o bengo-shita yori-mo ookuno bengoshi-ga shikaiin-kara
detective-ACC defended YORI-MO many lawyer-NOM city.council.person-from
wairo-o moratta
bribe-ACC received
'More employees than defended the detective took bribes from the city councilman.'

c. tantei-ga bengo-shita ookuno bengoshi-ga shikaiin-kara
detective-NOM defended many lawyer-NOM city.council.person-from
wairo-o moratta
bribe-ACC received
'Many employees that the detective defended took bribes from the city councilman.'

d. tantei-o bengo-shita ookuno bengoshi-ga shikaiin-kara wairo-o
detective-ACC defended many lawyer-NOM city.council.person-from bribe-ACC
moratta
received
'Many employees that defended the detective took bribes from the city councilman.'

12. a. otokonoko-ga kisushita yori-mo ookuno onnanoko-ga kyonen
boy-NOM kissed YORI-MO many girl-NOM last.year
barentainchoko-ACC ageta
valentine.chocolate-ACC gave
'More girls than the boy kissed gave him a valentine last year.'

b. otokonoko-ga kisushita yori-mo ookuno onnanoko-ga kyonen
boy-NOM kissed YORI-MO many girl-NOM last.year
barentainchoko-ACC ageta
valentine.chocolate-ACC gave

'More girls than kissed the boy gave him a valentine last year.'

c. otokonoko-ga kisushita yori-mo ookuno onnanoko-ga kyonen
boy-NOM kissed YORI-MO many girl-NOM last.year
barentainchoko-ACC ageta
valentine.chocolate-ACC gave

'Many girls who the boy kissed gave him a valentine last year.'

d. otokonoko-ga kisushita yori-mo ookuno onnanoko-ga kyonen
boy-NOM kissed YORI-MO many girl-NOM last.year
barentainchoko-ACC ageta
valentine.chocolate-ACC gave

'Many girls who kissed the boy gave him a valentine last year.'

13. a. sakkaasenshu-ga dakishimeta yori-mo ookuno chiimeeto-ga
soccer.player-NOM hugged YORI-MO many teammate-NOM
shiai-no-ato haitacchi-shita
match-GEN-after high.five-did

'More teammates than the soccer player hugged gave him a high-five after the game.'

b. sakkaasenshu-o dakishimeta yori-mo ookuno chiimeeto-ga shiai-no-ato
soccer.player-ACC hugged YORI-MO many teammate-NOM match-GEN-after
haitacchi-shita
high.five-did

'More teammates than hugged the soccer player gave him a high-five after the game.'

c. sakkaasenshu-ga dakishimeta ookuno chiimeeto-ga shiai-no-ato
soccer.player-NOM hugged many teammate-NOM match-GEN-after
haitacchi-shita
high.five-did

'Many teammates who the soccer player hugged gave him a high-five after the game.'

d. sakkaasenshu-o dakishimeta ookuno chiimeeto-ga shiai-no-ato
soccer.player-ACC hugged many teammate-NOM match-GEN-after
haitacchi-shita
high.five-did

'Many teammates who hugged the soccer player gave him a high-five after the game.'

14. a. butsurigakusha-ga touwaku-saseta yori-mo ookuno suugakusha-ga
physicist-NOM confused-made YORI-MO many mathematicians-NOM
daigaku-ni yatowareta
university-by were.hired

'More mathematicians than the physicists confused got hired by the university.'

b. butsurigakusha-o touwaku-saseta yori-mo ookuno suugakusha-ga
physicist-ACC confused-made YORI-MO many mathematicians-NOM
daigaku-ni yatowareta
university-by were.hired

'More mathematicians than confused the physicists got hired by the university.'

c. butsurigakusha-ga touwaku-saseta ookuno suugakusha-ga daigaku-ni
physicist-NOM confused-made many mathematicians-NOM university-by
yatowareta
were.hired

'Many mathematicians that the physicists confused got hired by the university.'

d. butsurigakusha-o touwaku-saseta ookuno suugakusha-ga daigaku-ni
physicist-ACC confused-made many mathematicians-NOM university-by
yatowareta
were.hired

'Many mathematicians that confused the physicists got hired by the university.'

15. a. baatendaa-ga nagutta yori-mo ookuno kyaku-ga tsuginohi-ni
bartender-NOM hit YORI-MO many customer-NOM next.day-DAT
futsukayoi-ninatta
second.day.drunk-became

'More customers than the bartender punched had a big hangover the next day.'

b. baatendaa-o nagutta yori-mo ookuno kyaku-ga tsuginohi-ni
bartender-ACC hit YORI-MO many customer-NOM next.day-DAT
futsukayoi-ninatta
second.day.drunk-became

'More customers than punched the bartender had a big hangover the next day.'

c. baatendaa-ga nagutta ookuno kyaku-ga tsuginohi-ni
bartender-NOM hit many customer-NOM next.day-DAT
futsukayoi-ninatta
second.day.drunk-became

'Many customers who the bartender punched had a big hangover the next day.'

d. baatendaa-o nagutta ookuno kyaku-ga tsuginohi-ni
bartender-ACC hit many customer-NOM next.day-DAT
futsukayoi-ninatta
second.day.drunk-became

'Many customers who punched the bartender had a big hangover the next day.'

16. a. tonii-ga ouen-shita yori-mo ookuno bokusaa-ga kinou-no-shiai-de
Tony-NOM supported YORI-MO many boxer-NOM yesterday-GEN-match-at
toppu-no-senshu-o ouenshita
top.rank-GEN-player-ACC supported

'More boxers than Tony supported rooted for the top-ranked fighter in yesterday's match.'

b. tonii-o ouen-shita yori-mo ookuno bokusaa-ga kinou-no-shiai-de
Tony-ACC supported YORI-MO many boxer-NOM yesterday-GEN-match-at
toppu-no-senshu-o ouenshita
top.rank-GEN-player-ACC supported

'More boxers than supported Tony rooted for the top-ranked fighter in yesterday's match.'

c. tonii-ga ouen-shita ookuno bokusaa-ga kinou-no-shiai-de
Tony-NOM supported many boxer-NOM yesterday-GEN-match-at
toppu-no-senshu-o ouenshita
top.rank-GEN-player-ACC supported

'Many boxers that Tony supported rooted for the top-ranked fighter in yesterday's match.'

d. tonii-o ouen-shita ookuno bokusaa-ga kinou-no-shiai-de
Tony-ACC supported many boxer-NOM yesterday-GEN-match-at
toppu-no-senshu-o ouenshita
top.rank-GEN-player-ACC supported

' Many boxers that supported Tony rooted for the top-ranked fighter in yesterday's match.'

17. a. choukokuka-ga hihansita yori-mo ooku-no gaka-ga bijutsushou-ni oubo-sita
sculptor-NOM criticized YORI-MO many-GEN artist-NOM art.prize-DAT applied

'More painters than the sculptor criticized applied for the prize.'

b. choukokuka-o hihansita yori-mo ooku-no gaka-ga bijutsushou-ni oubo-sita
sculptor-ACC criticized YORI-MO many-GEN artist-NOM art.prize-DAT applied

'More painters than criticized the sculptor applied for the prize.'

c. choukokuka-ga hihansita ooku-no gaka-ga bijutsushou-ni oubo-sita
sculptor-NOM criticized many-GEN artist-NOM art.prize-DAT applied

'Many painters who the sculptor criticized applied for the prize.'

d. choukokuka-o hihansita ooku-no gaka-ga bijutsushou-ni oubo-sita
sculptor-ACC criticized many-GEN artist-NOM art.prize-DAT applied

'Many painters who criticized the sculptor applied for the prize.'

18. a. rinjin-ga otozureta yori-mo otoshiyori-mo-ga samusa-o fusegu-tameni
neighbor-NOM visited YORI-MO elderly.people-NOM cold-ACC avoid-in.order.to
ie-no-naka-ni komotteita
house-GEN-inside-in retreated

'More elderly people than the neighbors visited shared some cookies from their pantries.'

b. rinjin-o otozureta yori-mo otoshiyori-mo-ga samusa-o fusegu-tameni
neighbor-ACC visited YORI-MO elderly.people-NOM cold-ACC avoid-in.order.to
ie-no-naka-ni komotteita
house-GEN-inside-in retreated

'More elderly people than visited the neighbors shared some cookies from their pantries.'

c. rinjin-ga otozureta otoshiyori-mo-ga samusa-o fusegu-tameni
neighbor-NOM visited elderly.people-NOM cold-ACC avoid-in.order.to
ie-no-naka-ni komotteita
house-GEN-inside-in retreated

'Many elderly people that the neighbors visited shared some cookies from their pantries.'

d. rinjin-o otozureta otoshiyori-mo-ga samusa-o fusegu-tameni
neighbor-ACC visited elderly.people-NOM cold-ACC avoid-in.order.to
ie-no-naka-ni komotteita
house-GEN-inside-in retreated

'Many elderly people that visited the neighbors shared some cookies from their pantries.'

19. a. Mary-ga hagemashita yori-mo sakkaa-senshu-ga Jane-o
Mary-NOM encouraged YORI-MO soccer-player-NOM Jane-ACC
ouensuru-kotonishita
root.for-decided.to

'More soccer players than Mary encouraged showed excellent sportsmanship.'

b. Mary-o hagemashita yori-mo sakkaa-senshu-ga Jane-o
Mary-ACC encouraged YORI-MO soccer-player-NOM Jane-ACC
ouensuru-kotonishita
root.for-decided.to

'More soccer players than encouraged Mary showed excellent sportsmanship.'

c. Mary-ga hagemashita sakkaa-senshu-ga Jane-o ouensuru-kotonishita
Mary-NOM encouraged soccer-player-NOM Jane-ACC root.for-decided.to

'Many soccer players that Mary encouraged showed excellent sportsmanship.'

d. Mary-o hagemashita sakkaa-senshu-ga Jane-o ouensuru-kotonishita
Mary-ACC encouraged soccer-player-NOM Jane-ACC root.for-decided.to

'Many soccer players that encouraged Mary showed excellent sportsmanship.'

20. a. daitouryou-ga utagatteita yori-mo ooku-no jouingiin-ga shigoto-o
president-NOM doubted YORI-MO many-GEN senator-NOM work-ACC
yoku-yatta
well-did

'More senators than the president doubted did their jobs well.'

b. daitouryou-o utagatteita yori-mo ooku-no jouingiin-ga shigoto-o
president-ACC doubted YORI-MO many-GEN senator-NOM work-ACC
yoku-yatta
well-did

'More senators than doubted the president did their jobs well.'

c. daitouryou-ga utagatteita ooku-no jouingiin-ga shigoto-o yoku-yatta
president-NOM doubted many-GEN senator-NOM work-ACC well-did

'Many senators that the president doubted did their jobs well.'

d. daitouryou-o utagatteita ooku-no jouingiin-ga shigoto-o yoku-yatta
president-ACC doubted many-GEN senator-NOM work-ACC well-did

'Many senators that doubted the president did their jobs well.'

21. a. onnanoko-ga tsunetta yori-mo ooku-no otokonoko-ga
girl-NOM pinched YORI-MO many-GEN boy-NOM
sore-wa-yokunai-koto-da-to wakatteita
that-TOP-not.good-thing-be-COMP understood

'More boys than the girls pinched knew that it wasn't a very nice thing to do.'

b. onnanoko-o tsunetta yori-mo ooku-no otokonoko-ga
girl-ACC pinched YORI-MO many-GEN boy-NOM
sore-wa-yokunai-koto-da-to wakatteita
that-TOP-not.good-thing-be-COMP understood

'More boys than pinched the girls knew that it wasn't a very nice thing to do.'

c. onnanoko-ga tsunetta ooku-no otokonoko-ga sore-wa-yokunai-koto-da-to
girl-NOM pinched many-GEN boy-NOM that-TOP-not.good-thing-be-COMP
wakatteita
understood

'Many boys that the girls pinched knew that it wasn't a very nice thing to do.'

d. onnanoko-o tsunetta ooku-no otokonoko-ga sore-wa-yokunai-koto-da-to
girl-ACC pinched many-GEN boy-NOM that-TOP-not.good-thing-be-COMP
wakatteita
understood

'Many boys that pinched the girls knew that it wasn't a very nice thing to do.'

22. a. kuugaa-ga koroshita yori-mo ookuno kuma-ga kawa-no sakana-o
cougar-NOM kille YORI-MO many bear-NOM river-GEN fish-ACC
tabeteita
were.eating

'More bears than the cougars killed would eat fish from the river.'

b. kuugaa-o koroshita yori-mo ookuno kuma-ga kawa-no sakana-o
cougar-ACC kille YORI-MO many bear-NOM river-GEN fish-ACC
tabeteita
were.eating

'More bears than killed the cougars would eat fish from the river.'

c. kuugaa-ga koroshita ookuno kuma-ga kawa-no sakana-o tabeteita
cougar-NOM kille many bear-NOM river-GEN fish-ACC were.eating

'Many bears that the cougars killed would eat fish from the river.'

d. kuugaa-o koroshita ookuno kuma-ga kawa-no sakana-o tabeteita
cougar-ACC kille many bear-NOM river-GEN fish-ACC were.eating

'Many bears that killed the cougars would eat fish from the river.'

23. a. moderu-ga kyohishita yori-mo ookuno koukokugaisha-ga yuumeina haiyuu-to
model-NOM rejected YORI-MO many advertising.agency famous actor-with
keiyaku-o musunda
contract-ACC tied

'More talent agents than the model rejected signed contracts with famous actors.'

b. moderu-o kyohishita yori-mo ookuno koukokugaisha-ga yuumeina haiyuu-to
model-ACC rejected YORI-MO many advertising.agency famous actor-with
keiyaku-o musunda
contract-ACC tied

'More talent agents than rejected the model signed contracts with famous actors.'

c. moderu-ga kyohishita ookuno koukokugaisha-ga yuumeina haiyuu-to
model-NOM rejected many advertising.agency famous actor-with
keiyaku-o musunda
contract-ACC tied

'Many talent agents that the model rejected signed contracts with famous actors.'

d. moderu-o kyohishita ookuno koukokugaisha-ga yuumeina haiyuu-to keiyaku-o
model-ACC rejected many advertising.agency famous actor-with contract-ACC
musunda
tied

'Many talent agents that rejected the model signed contracts with famous actors.'

24. a. heitai-ga mamotta yori-mo ookuno shougun-ga kichi-ni komotte
foot.soldier-NOM protected YORI-MO many general-NOM base-at stay.and
soko-kara joukyou-o miteita
there-from situation-ACC was-watching

'More generals than the troops protected stayed at the army base to see what happened.'

b. heitai-o mamotta yori-mo ookuno shougun-ga kichi-ni komotte
foot.soldier-ACC protected YORI-MO many general-NOM base-at stay.and
soko-kara joukyou-o miteita
there-from situation-ACC was-watching

'More generals than protected the troops stayed at the army base to see what happened.'

c. heitai-ga mamotta ookuno shougun-ga kichi-ni komotte soko-kara
foot.soldier-NOM protected many general-NOM base-at stay.and there-from
joukyou-o miteita
situation-ACC was-watching

'Many generals that the troops protected stayed at the army base to see what happened.'

d. heitai-o mamotta ookuno shougun-ga kichi-ni komotte soko-kara
foot.soldier-ACC protected many general-NOM base-at stay.and there-from
joukyou-o miteita
situation-ACC was-watching

'Many generals that protected the troops stayed at the army base to see what happened.'

25. a. jimotimin-ga shinyoushiteita yori-mo ookuno kankoukyaku-ga toshi-de-no
local.people-NOM trusted YORI-MO many traveler-NOM city-at-GEN
tabi-o tanoshinda
trip-ACC enjoyed

'More travelers than the locals trusted enjoyed their trip in the city.'

b. jimotimin-o shinyoushiteita yori-mo ookuno kankoukyaku-ga toshi-de-no
local.people-ACC trusted YORI-MO many traveler-NOM city-at-GEN
tabi-o tanoshinda
trip-ACC enjoyed

'More travelers than trusted the locals enjoyed their trip in the city.'

c. jimotimin-ga shinyoushiteita ookuno kankoukyaku-ga toshi-de-no tabi-o
local.people-NOM trusted many traveler-NOM city-at-GEN trip-ACC
tanoshinda
enjoyed

'Many travelers that the locals trusted enjoyed their trip in the city.'

d. jimotimin-o shinyoushiteita ookuno kankoukyaku-ga toshi-de-no tabi-o
local.people-ACC trusted many traveler-NOM city-at-GEN trip-ACC
tanoshinda
enjoyed

‘Many travelers that trusted the locals enjoyed their trip in the city.’

26. a. kenchikuka-ga tsureteitta yori-mo ookuno kougakusha-ga kenchikuhouki-no
architect-NOM brought YORI-MO many engineer-NOM building.code-GEN
zemi-ni itta
seminar-to went

‘More engineers than accompanied the architect attended the building code seminar.’

b. kenchikuka-o tsureteitta yori-mo ookuno kougakusha-ga kenchikuhouki-no
architect-ACC brought YORI-MO many engineer-NOM building.code-GEN
zemi-ni itta
seminar-to went

‘More engineers than the architect accompanied attended the building code seminar.’

c. kenchikuka-ga tsureteitta ookuno kougakusha-ga kenchikuhouki-no zemi-ni itta
architect-NOM brought many engineer-NOM building.code-GEN seminar-to went

‘Many engineers that accompanied the architect attended the building code seminar.’

d. kenchikuka-o tsureteitta ookuno kougakusha-ga kenchikuhouki-no zemi-ni itta
architect-ACC brought many engineer-NOM building.code-GEN seminar-to went

‘Many engineers that the architect accompanied attended the building code seminar.’

27. a. puroguramaa-ga tetsudatta yori-mo ookuno webudezainaa-ga atarashii
programmer-NOM helped YORI-MO many web.designer-NOM new
saito-no sagyou-de kuroushita
site-GEN work-with suffered

‘More web designers than helped the computer programmer had trouble getting the new website to work.’

b. puroguramaa-o tetsudatta yori-mo ookuno webudezainaa-ga atarashii
programmer-ACC helped YORI-MO many web.designer-NOM new
saito-no sagyou-de kuroushita
site-GEN work-with suffered

‘More web designers than the computer programmer helped had trouble getting the new website to work.’

c. puroguramaa-ga tetsudatta ookuno webudezainaa-ga atarashii saito-no
programmer-NOM helped many web.designer-NOM new site-GEN
sagyou-de kuroushita
work-with suffered

‘Many web designers that helped the computer programmer had trouble getting the new website to work.’

d. puroguramaa-o tetsudatta ookuno webudezainaa-ga atarashii saito-no
programmer-ACC helped many web.designer-NOM new site-GEN
sagyou-de kuroushita
work-with suffered

‘Many web designers that the computer programmer helped had trouble getting the new website to work.’

28. a. shuppansha-ga kaikoshita yori-mo ookuno yuumeisakka-ga totemo ninkina
publisher-NOM fired YORI-MO many famous.author-NOM very popular
shousetsu-o kaita
novel-ACC wrote

'More famous writers than fired the publisher wrote a really successful novel.'

b. shuppansha-o kaikoshita yori-mo ookuno yuumeisakka-ga totemo ninkina
publisher-ACC fired YORI-MO many famous.author-NOM very popular
shousetsu-o kaita
novel-ACC wrote

'More famous writers than the publisher fired wrote a really successful novel.'

c. shuppansha-ga kaikoshita ookuno yuumeisakka-ga totemo ninkina shousetsu-o
publisher-NOM fired many famous.author-NOM very popular novel-ACC
kaita
wrote

'Many famous writers that fired the publisher wrote a really successful novel.'

d. shuppansha-o kaikoshita ookuno yuumeisakka-ga totemo ninkina shousetsu-o
publisher-ACC fired many famous.author-NOM very popular novel-ACC
kaita
wrote

'Many famous writers that the publisher fired wrote a really successful novel.'

Experimental Materials, Chapter 5

Experiment 7

1. In the book, it says that more insects/mosquitoes than butterflies/a butterfly are commonly found near ponds.

2. On Tuesday, more doctors/nurses than surgeons/a surgeon worked the overnight shift at the hospital.

3. During the theft, more computers/cell phones than laptops/a laptop got stolen from the IT department.

4. The chef said that more shellfish/shrimp than oysters/an oyster were spoiled and couldn't be eaten.

5. In the past, more weapons/cigarettes than handguns/a handgun were smuggled through the border crossing.

6. The report showed that more birds/bears than eagles/an eagle were harmed in the forest fire.

7. As it turns out, more coins/dollar bills than dimes/a dime fell out of the overstuffed wallet.

8. It appears that more lizards/turtles than iguanas/an iguaga escaped from the terrarium.

9. At the meeting, more parents/fathers than mothers/a mother expressed concern about the public school system.

10. At the library, more stories/folk songs than fables/a fable kept the children's attention for the whole hour.

11. Apparently, more family members/friends than sisters/a sister were asked to be bridesmaids in the wedding.

12. The accountant said that more books/magazines than paperbacks/a paperback made profit for the publisher.

13. We heard that more scientists/historians than biologists/a biologist received an award from the University.

14. It seems that more flowers/violets than tulips/a tulip grew well in the small greenhouse.

15. Evidently, more Europeans/Americans than Italians/an Italian attended the international conference.

16. In all likelihood, more politicians/voters than senators/a senator were dreading the upcoming election campaign.

17. I think more dogs/cats than poodles/a poodle need to have their fur groomed regularly.

18. Last night, more desserts/appetizers than cakes/a cake were burnt by the new sous-chef.

19. This year, more candies/apples than lollipops/a lollipop got handed out on Hallowe'en night.

20. It's obvious that more buildings/houses than skyscrapers/a skyscraper sustained damage in the hurricane.

21. I could see that more tools/saws than hammers/a hammer were in the back of the contractor's truck.

22. At the antique shop, more rings/bracelets than wedding bands/a wedding band had engravings on the inside.

23. In general, more songs/movies than ballads/a ballad moved the teenaged girl to tears.

24. The manager said that more cocktails/soft drinks than martinis/a martini were served at the hotel's bar.

Experiment 8

1. In the book, it says that more insects/mosquitos than (just) butterflies are commonly found near ponds.

2. On Tuesday, more doctors/nurses than (just) surgeons worked the overnight shift at the hospital.

3. During the theft, more computers/cell phones than (just) laptops got stolen from the IT department.

4. The chef said that more shellfish/shrimp than (just) oysters were spoiled and couldn't be eaten.

5. In the past, more weapons/cigarettes than (just) handguns were smuggled through the border crossing.

6. As it turns out, more coins/dollar bills than (just) dimes fell out of the overstuffed wallet.
7. It appears that more lizards/turtles than (just) iguanas escaped from the terrarium.
8. The report showed that more birds/bears than (just) eagles were harmed in the forest fire.
9. At the meeting, more parents/fathers than (just) mothers expressed concern about the public school system.
10. At the library, more stories/folk songs than (just) fables kept the children's attention for the whole hour.
11. Apparently, more family members/friends than (just) sisters were asked to be bridesmaids in the wedding.
12. The accountant said that more books/magazines than (just) paperbacks made a profit for the publisher.
13. We heard that more scientists/historians than (just) biologists received an award from the University.
14. It seems that more flowers/violets than (just) tulips grew well in the small greenhouse.
15. At the house, more decorations/appliances than (just) posters were placed along the kitchen wall.
16. In all likelihood, more politicians/voters than (just) senators were dreading the upcoming election campaign.
17. I think more dogs/cats than (just) poodles need to have their fur groomed regularly.
18. Last night, more desserts/appetizers than (just) cakes were burnt by the new sous-chef.
19. This year, more candies/apples than (just) lollipops got handed out on Halloween night.
20. It's obvious that more buildings/houses than (just) skyscrapers sustained damage in the hurricane.
21. I could see that more tools/saws than (just) hammers were in the back of the contractor's truck.
22. At the antique shop, more rings/bracelets than (just) wedding bands had engravings on the inside.
23. In general, more songs/movies than (just) ballads moved the teenaged girl to tears.
24. The manager said that more cocktails/soft drinks than (just) martinis were served at the hotel's bar.

Experiment 9

1. a) Mary promoted more employees than she respected.
   b) Mary promoted more employees than the ones she respected.
   c) Mary fired more employees than she respected.
   d) Mary fired more employees than the ones she respected.

2. a) Linda reported more crimes than the ones she directly witnessed.
   b) Linda committed more crimes than she directly witnessed.
   c) Linda committed more crimes than the ones she directly witnessed.
   d) Linda reported more crimes than she directly witnessed.

3. a) Maurice hated more songs than he downloaded on iTunes.
   b) Maurice hated more songs than the ones he downloaded on iTunes.
   c) Maurice appreciated more songs than he downloaded on iTunes.
   d) Maurice appreciated more songs than the ones he downloaded on iTunes.

4. a) The librarian banned more books than the ones she ordered for the collection.
   b) The librarian read more books than she ordered for the collection.
   c) The librarian read more books than the ones she ordered for the collection.
   d) The librarian banned more books than she ordered for the collection.

5. a) The judge acquitted more defendants than he believed were innocent.
   b) The judge acquitted more defendants than the ones he believed were innocent.
   c) The judge convicted more defendants than he believed were innocent.
   d) The judge convicted more defendants than the ones he believed were innocent.

6. a) Zoey wrote fan letters to more athletes than the ones she admired.
   b) Zoey openly criticized more athletes than she admired.
   c) Zoey openly criticized more athletes than the ones she admired.
   d) Zoey wrote fan letters to more athletes than she admired.

7. a) Henry liked more people than he insulted outright.
   b) Henry liked more people than the ones he insulted outright.
   c) Henry disliked more people than he insulted outright.
   d) Henry disliked more people than the ones he insulted outright.

8. a) Reny ignored more old friends than the ones he greeted at the party.
   b) Reny recognized more old friends than he greeted at the party.
   c) Reny recognized more old friends than the ones he greeted at the party.
   d) Reny ignored more old friends than he greeted at the party.

9. a) The firefighter followed more protocols than he explained at the seminar.
   b) The firefighter followed more protocols than the ones he explained at the seminar.

c) The firefighter forgot more protocols than he explained at the seminar.

d) The firefighter forgot more protocols than the ones he explained at the seminar.

10. a) The mechanic test-drove more cars than the ones he repaired.

    b) The mechanic wrecked more cars than he repaired.

    c) The mechanic wrecked more cars than the ones he repaired.

    d) The mechanic test-drove more cars than he repaired.

11. a) Carrie snubbed more neighbours than she invited to her party.

    b) Carrie snubbed more neighbours than the ones she invited to her party.

    c) Carrie welcomed more neighbours than she invited to her party.

    d) Carrie welcomed more neighbours than the ones she invited to her party.

12. a) The copy editor overlooked more mistakes than the ones she found in the first chapter.

    b) The copy editor fixed more mistakes than she found in the first chapter.

    c) The copy editor fixed more mistakes than the ones she found in the first chapter.

    d) The copy editor overlooked more mistakes than she found in the first chapter.

13. a) The tourist took home more seashells than she found washed up on the beach.

    b) The tourist took home more seashells than the ones she found washed up on the beach.

    c) The tourist purchased more seashells than she found washed up on the beach.

    d) The tourist purchased more seashells than the ones she found washed up on the beach.

14. a) The realtor showed more homes than the ones she helped to re-decorate.

    b) The realtor inspected more homes than she helped to re-decorate.

    c) The realtor inspected more homes than the ones she helped to re-decorate.

    d) The realtor showed more homes than she helped to re-decorate.

15. a) The musician was unskilled at more instruments than he played expertly.

    b) The musician was unskilled at more instruments than the ones he played expertly.

    c) The musician owned more instruments than he played expertly.

    d) The musician owned more instruments than the ones he played expertly.

16. a) The contractor wasted more materials than the ones he used for the new project.

    b) The contractor ordered more materials than he used for the new project.

    c) The contractor ordered more materials than the ones he used for the new project.

    d) The contractor wasted more materials than he used for the new project.

Experimental Materials, Chapter 6

Experimental materials, Experiment 10

Order of conditions in the appendix: a) degree/match, b) cardinality, mismatch, c) degree, mismatch, d) cardinality, match.

1. a) John lifted heavier boxes onto the truck than Steve did, but smaller crates. Still, they both worked hard.
   b) John lifted heavier boxes onto the truck than Steve did, but fewer crates. Still, they both worked hard.
   c) John lifted more boxes onto the truck than Steve did, but smaller crates. Still, they both worked hard.
   d) John lifted more boxes onto the truck than Steve did, but fewer crates. Still, they both worked hard.

2. a) George owned faster cars during his career than Raymond did, but slower boats. George was jealous.
   b) George owned faster cars during his career than Raymond did, but fewer boats. George was jealous.
   c) George owned more cars during his career than Raymond did, but slower boats. George was jealous.
   d) George owned more cars during his career than Raymond did, but fewer boats. George was jealous.

3. a) Evan told funnier jokes at comedy night than Bob did, but duller anecdotes. Both routines were ok.
   b) Evan told funnier jokes at comedy night than Bob did, but fewer anecdotes. Both routines were ok.
   c) Evan told more jokes at comedy night than Bob did, but duller anecdotes. Both routines were ok.
   d) Evan told more jokes at comedy night than Bob did, but fewer anecdotes. Both routines were ok.

4. a) Tammy took earlier classes at the college than Henry did, and later lab sessions. She preferred lectures.
   b) Tammy took earlier classes at the college than Henry did, and fewer lab sessions. She preferred lectures.
   c) Tammy took more classes at the college than Henry did, and later lab sessions. She preferred lectures.
   d) Tammy took more classes at the college than Henry did, and fewer lab sessions. She preferred lectures.

5. a) Nancy cooked spicier side dishes for the meal than Liz did, and creamier desserts. Everything got eaten.
   b) Nancy cooked spicier side dishes for the meal than Liz did, and fewer desserts. Everything got eaten.

c) Nancy cooked more side dishes for the meal than Liz did, and creamier desserts. Everything got eaten.

d) Nancy cooked more side dishes for the meal than Liz did, and fewer desserts. Everything got eaten.

6. a) Cate wrote wittier novels in her life than Eric did, but sadder short stories. She was still very successful.

   b) Cate wrote wittier novels in her life than Eric did, but fewer short stories. She was still very successful.

   c) Cate wrote more novels in her life than Eric did, but sadder short stories. She was still very successful.

   d) Cate wrote more novels in her life than Eric did, but fewer short stories. She was still very successful.

7. a) The politican made harsher speeches than the activist did, and cleverer rebuttals. The election was near.

   b) The politican made harsher speeches than the activist did, and fewer rebuttals. The election was near.

   c) The politican made more speeches than the activist did, and cleverer rebuttals. The election was near.

   d) The politican made more speeches than the activist did, and fewer rebuttals. The election was near.

8. a) Kelly grew smaller flowers in the garden than Brian did, but healthier vegetables. They tasted great.

   b) Kelly grew smaller flowers in the garden than Brian did, but more vegetables. They tasted great.

   c) Kelly grew fewer flowers in the garden than Brian did, but healthier vegetables. They tasted great.

   d) Kelly grew fewer flowers in the garden than Brian did, but more vegetables. They tasted great.

9. a) Marc painted narrower hallways at the house than James did, but larger rooms. The colors were lovely.

   b) Marc painted narrower hallways at the house than James did, but more rooms. The colors were lovely.

   c) Marc painted fewer hallways at the house than James did, but larger rooms. The colors were lovely.

   d) Marc painted fewer hallways at the house than James did, but more rooms. The colors were lovely.

10. a) Sandra designed flimsier coats for the retailer than Allison did, but sturdier suits. The suits sold well.

    b) Sandra designed flimsier coats for the retailer than Allison did, but more suits. The suits sold well.

c) Sandra designed fewer coats for the retailer than Allison did, but sturdier suits. The suits sold well.

d) Sandra designed fewer coats for the retailer than Allison did, but more suits. The suits sold well.

11. a) Jack helped sicker patients at the hospital than Bonnie did, but kinder nurses. He felt appreciated.

b) Jack helped sicker patients at the hospital than Bonnie did, but more nurses. He felt appreciated.

c) Jack helped fewer patients at the hospital than Bonnie did, but kinder nurses. He felt appreciated.

d) Jack helped fewer patients at the hospital than Bonnie did, but more nurses. He felt appreciated.

12. a) Ally chose shabbier hotels last summer than Lisa did, but trendier restaurants. They spent a lot of money.

b) Ally chose shabbier hotels last summer than Lisa did, but more restaurants. They spent a lot of money.

c) Ally chose fewer hotels last summer than Lisa did, but trendier restaurants. They spent a lot of money.

d) Ally chose fewer hotels last summer than Lisa did, but more restaurants. They spent a lot of money.

13. a) Jen visited lonelier relatives over the holidays than Sal did, but happier friends. The visits were all fun.

b) Jen visited lonelier relatives over the holidays than Sal did, but more friends. The visits were all fun.

c) Jen visited fewer relatives over the holidays than Sal did, but happier friends. The visits were all fun.

d) Jen visited fewer relatives over the holidays than Sal did, but more friends. The visits were all fun.

14. a) Rufus attended wilder parties last summer than Tommy did, and classier art openings. But, they both had fun.

b) Rufus attended wilder parties last summer than Tommy did, and fewer art openings. But, they both had fun.

c) Rufus attended more parties last summer than Tommy did, and classier art openings. But, they both had fun.

d) Rufus attended more parties last summer than Tommy did, and fewer art openings. But, they both had fun.

15. a) Mary ate sweeter cupcakes at the party than Sue did, and tastier cookies. All of the food was great.

b) Mary ate sweeter cupcakes at the party than Sue did, and more cookies. All of the food was great.

c) Mary ate more cupcakes at the party than Sue did, and tastier cookies. All of the food was great.

d) Mary ate more cupcakes at the party than Sue did, and more cookies. All of the food was great.

16. a) The chef bought pricier steaks at the market than Phil did, and fancier mushrooms. The selection was superb.

 b) The chef bought pricier steaks at the market than Phil did, and more mushrooms. The selection was superb.

 c) The chef bought more steaks at the market than Phil did, and fancier mushrooms. The selection was superb.

 d) The chef bought more steaks at the market than Phil did, and more mushrooms. The selection was superb.

17. a) Melissa went to busier cafes downtown than Robert did, and snobbier bakeries. She's a real foodie.

 b) Melissa went to busier cafes downtown than Robert did, and more bakeries. She's a real foodie.

 c) Melissa went to more cafes downtown than Robert did, and snobbier bakeries. She's a real foodie.

 d) Melissa went to more cafes downtown than Robert did, and more bakeries. She's a real foodie.

18. a) Austin contacted wealthier donors for the charity than Ann did, and kinder volunteers. But, they both helped.

 b) Austin contacted wealthier donors for the charity than Ann did, and more volunteers. But, they both helped.

 c) Austin contacted more donors for the charity than Ann did, and kinder volunteers. But, they both helped.

 d) Austin contacted more donors for the charity than Ann did, and more volunteers. But, they both helped.

19. a) The gambler enjoyed riskier games than Molly did, and stronger drinks. He was fearless.

 b) The gambler enjoyed riskier games than Molly did, and more drinks. He was fearless.

 c) The gambler enjoyed more games than Molly did, and stronger drinks. He was fearless.

 d) The gambler enjoyed more games than Molly did, and more drinks. He was fearless.

20. a) Juan appraised rarer gemstones before the auction than Emma did, and older artifacts. The auction went well.

 b) Juan appraised rarer gemstones before the auction than Emma did, and more artifacts. The auction went well.

 c) Juan appraised more gemstones before the auction than Emma did, and older artifacts. The auction went well.

 d) Juan appraised more gemstones before the auction than Emma did, and more artifacts. The auction went well.

21. a) Jan sent ruder e-mail messages to his family than Ron did, and shorter letters. But they were both selfish.
    b) Jan sent ruder e-mail messages to his family than Ron did, and fewer letters. But they were both selfish.
    c) Jan sent fewer e-mail messages to his family than Ron did, and shorter letters. But they were both selfish.
    d) Jan sent fewer e-mail messages to his family than Ron did, and fewer letters. But they were both selfish.

22. a) Harry liked scarier movies in general than Stella did, and funnier books. He had more discerning taste.
    b) Harry liked scarier movies in general than Stella did, and fewer books. He had more discerning taste.
    c) Harry liked fewer movies in general than Stella did, and funnier books. He had more discerning taste.
    d) Harry liked fewer movies in general than Stella did, and fewer books. He had more discerning taste.

23. a) Vince raised skinnier cattle last year than Hannah did, and weaker goats. He wasn't a great farmer.
    b) Vince raised skinnier cattle last year than Hannah did, and fewer goats. He wasn't a great farmer.
    c) Vince raised fewer cattle last year than Hannah did, and weaker goats. He wasn't a great farmer.
    d) Vince raised fewer cattle last year than Hannah did, and fewer goats. He wasn't a great farmer.

24. a) Edna cleaned filthier windows over the weekend than Mia did, and dustier shelves. But the house is spotless.
    b) Edna cleaned filthier windows over the weekend than Mia did, and fewer shelves. But the house is spotless.
    c) Edna cleaned fewer windows over the weekend than Mia did, and dustier shelves. But the house is spotless.
    d) Edna cleaned fewer windows over the weekend than Mia did, and fewer shelves. But the house is spotless.

APPENDIX B

VERB BIASES, EXPERIMENT 5

(Biases from Gahl et al. (2004b))
(biases from Gahl et al. (2004b))

	Verb	PropDP	PropCP
CP-biased verbs			
	believe	0.04	0.73
	bet	0.05	0.28
	confess	0.19	0.31
	decide	0.03	0.33
	doubt	0.2	0.54
	guess	0.09	0.61
	realize	0.1	0.74
	report	0.17	0.23
	suggest	0.25	0.47
	suspect	0.2	0.32
	swear	0.18	0.24
	think	0.02	0.44
DP-biased verbs			
	accept	0.49	0.01
	establish	0.51	0.01
	find	0.44	0.13
	forget	0.46	0.08
	observe	0.47	0.11
	recall	0.56	0.12
	recognize	0.42	0.1
	reveal	0.58	0.2
	see	0.6	0.09
	sense	0.52	0.29
	signal	0.45	0.03
	understand	0.54	0.1

APPENDIX C

APPENDIX OF MODEL PARAMETERS

LME model tables, Chapter 2

Experiment 1

		Estimate	Std. Error	*t*- value
First-Pass Time				
Region 3	(Intercept)	311.267	14.242	21.856
	Sentence Type	8.516	17.753	0.480
	NP Type	-68.004	31.042	**-2.191**
	Trial Sequence	-0.423	1.097	-0.386
	Sentence Type x NP Type	-56.081	43.171	-1.299
Region 4	(Intercept)	346.6981	18.6627	18.577
	Sentence Type	1.4189	20.9129	0.068
	NP Type	-9.5768	18.7080	-0.512
	Trial Sequence	0.9037	0.9995	0.904
	Sentence Type x NP Type	-49.0251	34.0820	-1.438
Region 5	(Intercept)	349.7082	19.6884	17.762
	Sentence Type	15.0641	16.3829	0.919
	NP Type	22.9014	17.8750	1.281
	Trial Sequence	0.6349	1.0916	0.582
	Sentence Type x NP Type	-24.4457	32.2431	-0.758
Region 6	(Intercept)	659.0870	43.2017	15.256
	Sentence Type	-145.5957	40.9168	**-3.558**
	NP Type	-90.7839	36.7396	**-2.471**
	Trial Sequence	-0.6409	2.3124	-0.277
	Sentence Type x NP Type	-136.3629	74.6231	-1.827

		Estimate	Std. Error	*t*- value
Go-Past Time				
Region 3	(Intercept)	452.402	27.718	16.322
	Sentence Type	-36.584	40.510	-0.903
	NP Type	-6.541	54.753	-0.119
	Trial Sequence	-5.285	2.122	**-2.490**
	Sentence Type x NP Type	-151.435	78.677	-1.925
Region 4	(Intercept)	507.815	33.762	15.041
	Sentence Type	-81.944	49.242	-1.664
	NP Type	46.030	49.006	0.939
	Trial Sequence	-1.100	2.617	-0.420
	Sentence Type x NP Type	-298.008	93.500	**-3.187**
Region 5	(Intercept)	522.723	43.634	11.980
	Sentence Type	178.151	61.511	**2.896**
	NP Type	-1.608	49.627	-0.032
	Trial Sequence	-1.202	2.950	-0.407
	Sentence Type x NP Type	-112.609	117.825	-0.956
Region 6	(Intercept)	1538.032	143.956	10.684
	Sentence Type	439.486	117.441	**3.742**
	NP Type	307.306	131.113	**2.344**
	Trial Sequence	-15.734	5.543	**-2.839**
	Sentence Type x NP Type	260.163	201.907	1.289

		Estimate	Std. Error	*t*- value
Total Time				
Region 3	(Intercept)	486.950	37.679	12.924
	Sentence Type	23.692	41.457	0.571
	NP Type	-19.028	45.557	-0.418
	Trial Sequence	-4.791	2.011	**-2.382**
	Sentence Type x NP Type	-120.565	60.349	*-1.998*
Region 4	(Intercept)	632.988	47.014	13.464
	Sentence Type	182.207	55.350	**3.292**
	NP Type	134.367	42.334	**3.174**
	Trial Sequence	-2.304	2.120	-1.087
	Sentence Type x NP Type	-64.910	64.824	-1.001
Region 5	(Intercept)	524.803	38.469	13.642
	Sentence Type	193.468	35.530	**5.445**
	NP Type	124.971	38.213	**3.270**
	Trial Sequence	-4.666	1.904	**-2.451**
	Sentence Type x NP Type	54.036	60.815	0.889
Region 6	(Intercept)	999.661	69.174	14.451
	Sentence Type	71.546	49.136	1.456
	NP Type	51.486	44.851	1.148
	Trial Sequence	-6.714	2.462	**-2.727**
	Sentence Type x NP Type	146.620	76.786	*1.909*

		Estimate	Std. Error	*z*- value	*p*-value
Regressions Out					
Region 3	(Intercept)	-1.32788	0.18082	-7.344	<.001
	Sentence Type	-0.20938	0.29691	-0.705	0.481
	NP Type	-0.01350	0.26678	-0.051	0.960
	Trial Sequence	-0.04786	0.01786	-2.680	**0.007**
	Sentence Type x NP Type	0.06701	0.62773	0.107	0.915
Region 4	(Intercept)	-2.020547	0.254374	-7.943	<.001
	Sentence Type	-0.837087	0.333215	-2.512	**0.012**
	NP Type	0.271025	0.301522	0.899	0.369
	Trial Sequence	-0.006874	0.018937	-0.363	0.717
	Sentence Type x NP Type	-2.699524	0.672129	-4.016	**<.001**
Region 5	(Intercept)	-1.936706	0.247707	-7.819	<.001
	Sentence Type	1.403266	0.350918	3.999	**<.001**
	NP Type	0.265421	0.343671	0.772	0.440
	Trial Sequence	-0.009247	0.019928	-0.464	0.643
	Sentence Type x NP Type	-1.800882	0.739398	-2.436	**0.015**
Region 6	(Intercept)	-0.22226	0.28369	-0.783	0.433
	Sentence Type	0.91259	0.26749	3.412	**<.001**
	NP Type	0.79467	0.33279	2.388	**0.017**
	Trial Sequence	-0.04006	0.01597	-2.509	**0.012**
	Sentence Type x NP Type	1.12022	0.52845	2.120	**0.034**

		Estimate	Std. Error	*z*- value	*p*-value
Regressions In					
Region 3	(Intercept)	-0.97778	0.16273	-6.008	<.001
	Sentence Type	0.40862	0.26123	1.564	0.118
	NP Type	0.73608	0.22356	3.293	<**.001**
	Trial Sequence	-0.04427	0.01576	-2.808	**0.005**
	Sentence Type x NP Type	-0.49996	0.48713	-1.026	0.305
Region 4	(Intercept)	-0.83008	0.27322	-3.038	0.002
	Sentence Type	1.96126	0.38154	5.140	<**.001**
	NP Type	0.92328	0.25145	3.672	<**.001**
	Trial Sequence	-0.03687	0.01698	-2.171	**0.030**
	Sentence Type x NP Type	0.53076	0.66084	0.803	0.422
Region 5	(Intercept)	-1.12381	0.24830	-4.526	<.001
	Sentence Type	0.78720	0.31355	2.511	**0.012**
	NP Type	0.53628	0.29444	1.821	*0.069*
	Trial Sequence	-0.03376	0.01678	-2.012	**0.0443**
	Sentence Type x NP Type	1.07339	0.61813	1.737	*0.0825*

LME Model tables, Chapter 3

Experiment 2

		Estimate	Std. Error	*t*- value
Initial region (*more NPs*)	Intercept	772.66	38.56	**20.036**
	Gap Type	-19.84	17.77	-1.117
	Than-Position	10.73	17.77	0.609
	Gap Type x *Than*-Position	15.25	33.40	0.457
Than-phrase region	Intercept	1086.38	48.14	**22.565**
	Gap Type	71.65	33.53	**2.137**
	Than-Position	-29.78	36.50	-0.816
	Gap Type x *Than*-Position	-103.44	81.03	-1.277
Main VP region	Intercept	1387.51	80.53	**17.230**
	Gap Type	71.08	35.08	**2.026**
	Than-Position	-158.64	38.21	**-4.152**
	Gap Type x *Than*-Position	-74.23	69.02	-1.075
Than-phrase +	Intercept	2462.13	106.61	**23.095**
Main VP Region	Gap Type	141.10	51.26	**2.753**
(Regions 2+3)	*Than*-Position	-182.79	62.56	**-2.922**
	Gap Type x *Than*-Position	-135.40	115.56	-1.172
Continuation region	Intercept	1427.37	77.48	**18.422**
	Gap Type	-46.20	35.71	-1.294
	Than-Position	39.57	32.28	1.226
	Gap Type x *Than*-Position	-14.86	64.48	-0.230

Experiment 3

		Estimate	Std. Error	*t*- value
Initial region (*More NPs* or *The NPs*)	Intercept	692.084	33.521	**20.646**
	Clause Type	-130.491	21.617	**-6.036**
	Gap Type	6.209	22.002	0.282
	Clause Type x Gap Type	39.152	45.131	0.868
Than-phrase/ RC region	Intercept	1723.85	105.69	**16.310**
	Clause Type	-470.09	57.96	**-8.110**
	Gap Type	63.24	75.97	0.833
	Clause Type x Gap Type	-701.47	132.48	**-5.295**
Main VP region	Intercept	1308.40	79.55	**16.447**
	Clause Type	-93.92	48.77	*-1.926*
	Gap Type	-149.29	49.89	**-2.992**
	Clause Type x Gap Type	60.00	82.09	0.731
Continuation region	Intercept	1021.51	62.04	**16.465**
	Clause Type	56.19	41.34	1.359
	Gap Type	25.16	38.99	0.645
	Clause Type x Gap Type	23.45	89.00	0.263

Experiment 5

		Estimate	Std. Error	*t*- value
Most deeply embedded clause region	Intercept	1359.48	116.14	**11.705**
	Verb Bias	174.64	66.15	**2.640**
	Gap Type	21.24	58.64	0.362
	Verb Bias x Gap Type	147.65	98.32	1.502
Spillover region	Intercept	641.178	33.245	**19.287**
	Verb Bias	13.404	24.057	0.557
	Gap Type	-77.074	22.720	**-3.392**
	Verb Bias x Gap Type	-9.344	44.448	-0.210

LME model parameters, Chapter 4

Experiment 6

		Estimate	Std. Error	*t*- value
Yori-mo	Intercept	718.22	55.60	**12.918**
	Gap Type	77.06	47.98	1.606
(Random slope for interaction not included in the model)				
Ooku-no	Intercept	679.037	50.203	**13.526**
	Clause Type	18.798	42.724	0.440
	Gap Type	3.971	39.729	0.100
	Clause Type x Gap Type	-66.951	67.373	-0.994
Associate of Comparison	Intercept	1111.82	94.25	**11.796**
	Clause Type	-125.54	93.38	-1.345
	Gap Type	146.09	83.83	1.743
	Clause Type x Gap Type	-297.52	188.47	-1.579
Spillover region	Intercept	868.43	49.85	**17.422**
	Clause Type	-161.71	53.67	**-3.013**
	Gap Type	-21.62	49.87	-0.434
	Clause Type x Gap Type	-63.81	111.96	-0.570

LME model parameters, Chapter 5

Experiment 7

First-Pass Time

		Estimate	Std. Error	*t*- value
Region 1	Intercept	416.203	45.472	**9.153**
	Type	28.157	16.234	1.734
	Complement	-6.256	17.668	-0.354
	Trial Sequence	-0.744	1.169	-0.637
	Type x Complement	58.337	36.485	1.599

		Estimate	Std. Error	*t*- value
Region 2	Intercept	461.6596	22.4303	**20.582**
	Type	-46.2233	17.7429	**-2.605**
	Complement	-19.1518	13.9173	-1.376
	Trial Sequence	-0.2398	0.9688	-0.248
	Type x Complement	-14.4638	33.0685	-0.437

		Estimate	Std. Error	*t*- value
Region 3	Intercept	269.0142	11.5137	**23.365**
	Type	5.9731	13.2000	0.453
	Complement	9.3290	11.1123	-0.840
	Trial Sequence	0.7392	0.7335	1.008
	Type x Complement	14.0736	21.8437	0.644

		Estimate	Std. Error	*t*- value
Region 4	Intercept	312.6442	16.7050	**18.716**
	Type	-17.2204	12.0639	-1.427
	Complement	62.0626	13.2385	**4.688**
	Trial Sequence	-1.2760	0.7936	-1.608
	Type x Complement	-25.2800	21.8587	-1.157

(Random slopes for interactions removed from the model due to a singular convergence)

		Estimate	Std. Error	*t*- value
Region 5	Intercept	342.0267	17.3690	**19.692**
	Type	4.7240	12.4744	0.379
	Complement	10.3598	12.0116	0.862
	Trial Sequence	0.8818	0.7095	1.243
	Type x Complement	1.0325	25.9047	0.040

		Estimate	Std. Error	*t*- value
Region 6	Intercept	890.8816	58.6095	**15.200**
	Type	11.4462	34.9677	0.327
	Complement	63.0106	40.9872	1.537
	Trial Sequence	-0.3224	2.1901	-0.147
	Type x Complement	103.8614	77.1704	1.346

		Estimate	Std. Error	*t*- value
Region 6 (w/ Trial Seq)	Intercept	893.3921	58.8423	**15.183**
	Type	5.4260	36.3876	0.149
	Complement	59.0980	39.5713	1.493
	Trial Sequence	-0.7621	2.1834	-0.349
	Type x Complement	109.4948	76.0396	1.440
	Type x Trial Seq	2.0564	4.4422	0.463
	Complement x Trial Seq	8.8652	4.4427	*1.995*
	Type x Comp. x Trial Seq	-27.7708	8.7566	**-3.171**

Go-Past Time

		Estimate	Std. Error	*t*- value
Region 1	Intercept	416.203	45.472	**9.153**
	Type	28.157	16.234	1.734
	Complement	-6.256	17.668	-0.354
	Trial Sequence	-0.744	1.169	-0.637
	Type x Complement	58.337	36.485	1.599

		Estimate	Std. Error	*t*- value
Region 2	Intercept	543.711	27.470	**19.793**
	Type	-61.684	27.579	**-2.237**
	Complement	2.177	25.031	0.087
	Trial Sequence	-2.012	1.316	-1.529
	Type x Complement	-20.346	44.252	-0.460

		Estimate	Std. Error	*t*- value
Region 3	Intercept	311.2707	18.8462	**16.516**
	Type	23.3469	22.2230	1.051
	Complement	-21.2517	23.7030	-0.897
	Trial Sequence	0.3825	1.3010	0.294
	Type x Complement	39.6981	44.6458	0.889

		Estimate	Std. Error	*t*- value
Region 4	Intercept	426.831	22.263	**19.172**
	Type	-36.304	24.170	-1.502
	Complement	156.961	25.812	**6.08**1
	Trial Sequence	-2.877	1.332	**-2.160**
	Type x Complement	-55.319	45.731	-1.210

		Estimate	Std. Error	*t*- value
Region 5	Intercept	403.623	23.694	**17.035**
	Type	13.358	19.872	0.672
	Complement	77.420	24.748	**3.128**
	Trial Sequence	-1.125	1.210	-0.930
	Type x Complement	25.949	40.871	0.635

		Estimate	Std. Error	*t*- value
Region 6	Intercept	1400.510	128.026	**10.939**
	Type	139.519	85.393	1.634
	Complement	-24.964	51.624	-0.484
	Trial Sequence	-6.371	3.689	-1.727
	Type x Complement	-134.208	100.444	-1.336

Regressions Out

Region 2		Estimate	Std. Error	*z*- value	*p*- value
	Intercept	-2.59433	0.25292	-10.258	**< 2e-16**
	Type	-0.12648	0.31060	-0.407	0.68386
	Complement	0.90151	0.32588	2.766	**0.00567**
	Trial Sequence	-0.03341	0.01768	-1.890	*0.05877*
	Type x Complement	-0.17936	0.57888	-0.310	0.75668

Region 3		Estimate	Std. Error	*z*- value	*p*- value
	Intercept	-3.4300228	0.3189886	-10.753	**<2e-16**
	Type	1.1132018	0.5436744	2.048	**0.0406**
	Complement	-0.9053504	0.5996009	-1.510	0.1311
	Trial Sequence	-0.0007891	0.0298786	-0.026	0.9789
	Type x Complement	2.1744727	1.1333797	1.919	*0.0550*

Region 4		Estimate	Std. Error	*z*- value	*p*- value
	Intercept	-1.297585	0.209957	-6.180	**6.40e-10**
	Type	-0.079235	0.211264	-0.375	0.7076
	Complement	0.891583	0.208827	4.269	**1.96e-05**
	Trial Sequence	-0.003216	0.013269	-0.242	0.8085
	Type x Complement	0.654946	0.380469	1.721	*0.0852*

(Random slopes for interactions removed from the model
due to a singular convergence)

Region 5		Estimate	Std. Error	*z*- value	*p*- value
	Intercept	-2.91849	0.23636	-12.348	**< 2e-16**
	Type	-0.02995	0.33847	-0.088	0.92950
	Complement	1.29815	0.34386	3.775	**0.00016**
	Trial Sequence	-0.04712	0.02149	-2.193	**0.02829**
	Type x Complement	0.36878	0.64982	0.568	0.57037

(Random slopes for interactions and
random slope for complement
type by items removed from the model
due to a singular convergence)

Region 6		Estimate	Std. Error	*z*- value	*p*-value
	Intercept	-1.16465	0.23792	-4.895	**9.82e-07**
	Type	0.19332	0.19750	0.979	0.3276
	Complement	-0.47369	0.19158	-2.473	**0.0134**
	Trial Sequence	-0.02843	0.01319	-2.156	**0.0311**
	Type x Complement	-0.99499	0.39200	-2.538	**0.0111**

		Estimate	Std. Error	*z*- value	*p*-value
Region 6 w/ trial seq	Intercept	-1.20551	0.24709	-4.879	**1.07e-06**
	Type	0.21803	0.20925	1.042	0.29743
	Complement	-0.48300	0.20129	-2.400	**0.01641**
	Trial Sequence	-0.02693	0.01378	-1.954	*0.05070*
	Type x Complement	-0.92970	0.37022	-2.511	**0.01203**
	Type x Trial Seq	-0.08793	0.02790	-3.151	**0.00162**
	Complement x Trial Seq	-0.06328	0.02816	-2.247	**0.02461**
	Type x Comp. x Trial Seq	0.10987	0.05569	1.973	**0.04852**
	(Random slopes for interactions removed from the model due to a singular convergence)				

Model Parameters, Experiment 8

First Pass Time

Region 1

	Estimate	Std. Error	*t*- value
Intercept	350.1399	35.5298	**9.855**
Type	8.6371	20.0939	0.430
Just	-8.6079	16.3092	-0.528
Trial Sequence	-0.2181	1.0609	-0.206
Type x Just	-10.1256	37.0688	-0.273

Region 2

	Estimate	Std. Error	*t*- value
Intercept	383.4188	16.4687	**23.282**
Type	-8.8625	17.7051	-0.501
Just	-0.5778	16.7844	-0.034
Trial Sequence	-2.7668	1.0220	**-2.707**
Type x Just	47.5811	36.7232	1.296

Region 3

	Estimate	Std. Error	*t*- value
Intercept	232.4112	10.2242	**22.731**
Type	1.1899	12.3221	0.097
Just	6.4185	11.3435	0.566
Trial Sequence	0.6548	0.7774	0.842
Type x Just	-21.6182	25.4475	-0.850

Region 4

	Estimate	Std. Error	*t*- value
Intercept	228.07905	11.25678	**20.261**
Type	15.83119	21.43190	0.739
Trial Sequence	-0.05419	0.81354	-0.067

Region 5

	Estimate	Std. Error	*t*- value
Intercept	259.1142	11.6023	**22.333**
Type	19.5625	12.7632	1.533
Just	-1.3218	15.5542	-0.085
Trial Sequence	-0.3255	0.7998	-0.407
Type x Just	-7.0019	21.6537	-0.323

(Random slopes for interactions removed from the model due to a singular convergence)

		Estimate	Std. Error	*t*- value
	Intercept	302.955	15.215	**19.912**
Region 6	Type	-22.572	14.504	-1.556
	Just	9.813	12.252	0.801
	Trial Sequence	1.234	0.839	1.471
	Type x Just	20.986	28.315	0.741

		Estimate	Std. Error	*t*- value
	Intercept	263.3268	15.5775	**16.904**
Region 7	Type	-4.9890	17.2678	-0.289
	Just	9.4411	14.2006	0.665
	Trial Sequence	0.3769	0.9121	0.413
	Type x Just	-12.4047	27.7037	-0.448

		Estimate	Std. Error	*t*- value
	Intercept	287.0555	16.1410	**17.784**
Region 8	Type	-18.9815	16.5355	-1.148
	Just	14.9651	12.4709	1.200
	Trial Sequence	0.7463	0.8864	0.842
	Type x Just	10.4145	30.0450	0.347

Go-Past Time

Region 1

	Estimate	Std. Error	*t*- value
Intercept	350.1399	35.5298	**9.855**
Type	8.6371	20.0939	0.430
Just	-8.6079	16.3092	-0.528
Trial Sequence	-0.2181	1.0609	-0.206
Type x Just	-10.1256	37.0688	-0.273

Region 2

	Estimate	Std. Error	*t*- value
Intercept	452.231	25.442	**17.775**
Type	-66.937	30.714	**-2.179**
Just	-19.267	23.571	-0.817
Trial Sequence	-4.169	1.374	**-3.034**
Type x Just	111.062	52.055	**2.134**

Region 3

	Estimate	Std. Error	*t*- value
Intercept	276.3734	16.5493	**16.700**
Type	-18.0050	25.4217	-0.708
Just	-13.8727	25.3129	-0.548
Trial Sequence	0.2721	1.5071	0.181
Type x Just	41.9407	42.2218	0.993

(Random slopes for interactions removed from the model due to a singular convergence)

Region 4

	Estimate	Std. Error	*t*- value
Intercept	282.178	17.286	**16.324**
Type	27.332	26.629	1.026
Trial Sequence	-2.011	1.816	-1.108

Region 5

	Estimate	Std. Error	*t*- value
Intercept	325.970	19.612	**16.621**
Type	64.093	26.447	**2.423**
Just	28.097	25.923	1.084
Trial Sequence	-4.382	1.408	**-3.114**
Type x Just	87.616	58.162	1.506

		Estimate	Std. Error	*t*- value
Region 6	Intercept	336.4761	16.4018	**20.515**
	Type	-29.1522	23.9777	-1.216
	Just	22.2267	24.8410	0.895
	Trial Sequence	0.6532	1.1841	0.552
	Type x Just	77.4234	54.5381	1.420

		Estimate	Std. Error	*t*- value
Region 6 (w/ interactions)	Intercept	334.2494	16.4325	**20.341**
	Type	-29.7363	23.6792	-1.256
	Just	23.6442	25.2346	0.937
	Trial Sequence	0.7600	1.1753	0.647
	Type x Just	71.1524	56.2456	1.265
	Type x Trial Seq	0.8396	2.3765	0.353
	Just x Trial Seq	7.5177	2.3782	**3.161**
	Type x Just x Seq	-2.4621	4.7399	-0.519

		Estimate	Std. Error	*t*- value
Region 7	Intercept	315.000	23.820	**13.224**
	Type	-14.181	25.380	-0.559
	Just	3.808	22.474	0.169
	Trial Sequence	2.339	1.466	1.596
	Type x Just	-22.433	39.215	-0.572

(Random slopes for interactions removed from the model due to a singular convergence)

		Estimate	Std. Error	*t*- value
Region 8	Intercept	318.52115	17.15742	**18.565**
	Type	-22.58949	24.03291	-0.940
	Just	31.75635	24.18011	1.313
	Trial Sequence	0.09483	1.22480	0.077
	Type x Just	62.22985	50.95668	1.221

Regressions Out

		Estimate	Std. Error	*z*- value	*p*- value
	Intercept	-2.70711	0.22028	-12.289	**<2e-16**
Region 2	Type	-0.79049	0.42871	-1.844	*0.0652*
	Just	-0.64429	0.38618	-1.668	*0.0952*
	Trial Sequence	-0.02072	0.02385	-0.869	0.3848
	Type x Just	0.07332	0.97090	0.076	0.9398

		Estimate	Std. Error	*z*- value	*p*- value
	Intercept	-2.57616	0.27429	-9.392	**<2e-16**
Region 3	Type	-0.38788	0.47456	-0.817	0.4137
	Just	-0.67913	0.52779	-1.287	0.1982
	Trial Sequence	-0.05432	0.03269	-1.662	*0.0966*
	Type x Just	-0.03872	0.93054	-0.042	0.9668

		Estimate	Std. Error	*z*- value	*p*- value
Region 4	Intercept	-2.18532	0.36339	-6.014	**1.81e-09**
	Type	-0.19989	0.47943	-0.417	0.677
	Trial Sequence	-0.05410	0.03636	-1.488	0.137

(Random slopes for interactions removed from the model due to a singular convergence)

		Estimate	Std. Error	*z*- value	*p*- value
	Intercept	-1.99722	0.23225	-8.600	**<2e-16**
Region 5	Type	0.12557	0.30415	0.413	0.6797
	Just	0.66233	0.35129	1.885	*0.0594*
	Trial Sequence	-0.04466	0.02045	-2.183	**0.0290**
	Type x Just	1.64525	0.69751	2.359	**0.0183**

		Estimate	Std. Error	*z*- value	*p*- value
	Intercept	-3.545867	0.340553	-10.412	**<2e-16**
Region 6	Type	-0.396813	0.604787	-0.656	0.5117
	Just	1.078589	0.643301	1.677	*0.0936*
	Trial Sequence	0.009272	0.033186	0.279	0.7799
	Type x Just	2.119422	1.149931	1.843	*0.0653*

(Random slopes for interactions removed from the model due to a false convergence)

		Estimate	Std. Error	*z*- value	*p*- value
Region 7	Intercept	-2.46384	0.28872	-8.534	**<2e-16**
	Type	-0.87245	0.40983	-2.129	0.0333
	Just	-0.34090	0.38087	-0.895	0.3708
	Trial Sequence	0.05090	0.02586	1.968	**0.0490**
	Type x Just	-0.64930	0.80991	-0.802	0.4227

		Estimate	Std. Error	*z*- value	*p*- value
Region 8	Intercept	-1.35558	0.27519	-4.926	**8.4e-07**
	Type	0.02270	0.25282	0.090	0.928
	Just	0.19300	0.30749	0.628	0.530
	Trial Sequence	-0.02755	0.01685	-1.635	0.102
	Type x Just	-0.29603	0.47941	-0.617	0.537

LME model parameters, Chapter 6

Experiment 10

		Estimate	Std. Error	*t*- value
First-Pass Time				
Region 1	Intercept	421.132	25.643	**16.423**
	Adjective 1	-1.556	17.039	-0.091
	Match	-25.531	19.691	-1.297
	Trial sequence	-2.668	1.211	**-2.204**
	Adjective 1 * Match	25.560	38.338	0.667
Region 2	Intercept	491.0518	28.1724	**17.430**
	Adjective 1	141.7929	31.1816	**4.547**
	Match	-26.8131	21.7567	-1.232
	Trial sequence	-0.9236	1.2866	-0.718
	Adjective 1 * Match	-35.1463	39.6640	-0.911
Region 2 (length and log frequency included)	Intercept	490.8416	27.7777	**17.670**
	Adjective 1	17.7453	62.9543	0.282
	Match	-26.2749	21.5315	-1.220
	Trial sequence	-0.8077	1.2853	-0.628
	Log Frequency	-28.1614	15.1318	-1.861
	Length	23.1870	26.8620	0.863
	Adjective 1 * Match	-35.7567	39.5553	-0.904
Region 3 (22 items)	Intercept	407.5436	22.3697	**18.219**
	Adjective 1	-6.6424	17.1620	-0.387
	Match	-11.7276	11.8779	-0.987
	Trial sequence	-0.4186	0.8337	-0.502
	Adjective 1 * Match	34.2194	22.6231	1.513
	Note: Random slopes for the interaction not included.			

Region 4	Intercept	448.9755	22.1164	**20.301**
	Adjective 2	7.6060	14.3887	0.529
	Match	18.1599	16.6714	1.089
	Trial sequence	-4.0526	0.8816	**-4.597**
	Adjective 2 * Match	21.0531	28.5559	0.737
Region 5	Intercept	662.814	33.306	**19.900**
	Adjective 2	139.503	54.026	2.582
	Match	24.106	22.178	1.087
	Trial sequence	-5.425	1.221	**-4.441**
	Log Frequency	–21.896	15.615	-1.402
	Length	-13.165	26.362	-0.499
	Adjective 2 * Match	69.165	40.354	1.714
Region 6	Intercept	7.010	22.034	0.318
	Adjective 2	-1.180	21.548	-0.055
	Match	7.010	22.034	0.318
	Trial sequence	-4.995	1.541	**-3.242**
	Adjective 2 * Match	-29.857	45.273	-0.659

		Estimate	Std. Error	*t*- value
Go-Past Time				
Region 1	Intercept	421.132	25.643	**16.423**
	Adjective 1	-25.531	19.691	-1.297
	Match	-1.556	17.039	-0.091
	Trial sequence	-2.668	1.211	**-2.204**
	Adjective 1 * Match	25.560	38.338	0.667
Region 2	Intercept	700.439	45.633	**15.349**
	Adjective 1	244.150	32.304	**7.558**
	Match	22.007	22.484	0.979
	Trial sequence	-2.161	1.588	-1.361
	Adjective 1 * Match	-39.243	45.674	-0.859
Region 2	Intercept	699.983	43.949	**15.927**
(length and	Adjective 1	277.241	69.979	**3.962**
log frequency included)	Match	22.436	22.379	1.003
	Trial sequence	-2.110	1.589	-1.328
	Log Frequency	-43.227	16.565	**-2.610**
	Length	-50.827	27.203	-1.868
	Adjective 1 * Match	-38.237	45.409	-0.842
Region 3	Intercept	453.367	26.219	**17.291**
	Adjective 1	0.705	26.822	0.026
	Match	15.623	21.889	0.714
	Trial sequence	-2.171	1.314	-1.652
	Adjective 1 * Match	14.519	44.161	0.329

Region 4	Intercept	530.346	29.296	**18.103**
	Adjective 2	29.746	22.113	1.345
	Match	8.501	22.743	0.374
	Trial sequence	-6.021	1.453	**-4.145**
	Adjective 2 * Match	-35.787	48.785	-0.734
Region 5	Intercept	746.687	45.514	**16.406**
	Adjective 2	225.711	72.859	**3.098**
	Match	32.925	26.806	1.228
	Trial sequence	-3.308	1.948	-1.698
	Log Frequency	-32.822	21.484	-1.528
	Length	-48.377	35.716	-1.354
	Adjective 2 * Match	110.591	54.603	**2.025**
Region 5, Simple effects				
Degree items				
	Intercept	828.643	52.769	**15.703**
	Match	80.712	39.061	**2.066**
	Trial sequence	-4.238	2.874	-1.475
Cardinality items				
	Intercept	660.055	41.319	**15.975**
	Match	-20.572	33.669	-0.611
	Trial sequence	-3.255	2.486	-1.309
Region 6	Intercept	1040.615	65.012	**16.006**
	Adjective 2	-68.308	58.238	-1.173
	Match	13.033	51.772	0.252
	Trial sequence	-17.777	3.715	**-4.785**
	Adjective 2 * Match	59.993	124.749	0.481

		Estimate	Std. Error	*t*- value
Total Time				
Region 1	Intercept	549.079	49.664	**11.056**
	Adjective 1	-4.440	25.194	-0.176
	Match	-13.835	23.037	-0.601
	Trial sequence	-4.855	1.483	**-3.273**
	Adjective 1 * Match	39.594	47.561	0.832
Region 2	Intercept	714.808	46.891	**15.244**
	Adjective 1	234.349	33.211	**7.056**
	Match	14.456	23.519	0.615
	Trial sequence	-4.475	1.600	- **2.797**
	Adjective 1 * Match	-13.637	46.841	-0.291
Region 2 (length and log frequency included)	Intercept	714.222	45.230	**15.791**
	Adjective 1	217.957	72.865	**2.991**
	Match	14.824	23.898	0.620
	Trial sequence	-4.526	1.600	**-2.829**
	Log Frequency	-44.121	16.277	**-2.711**
	Length	-32.615	30.055	-1.085
	Adjective 1 * Match	-11.683	45.372	-0.258
Region 3	Intercept	03.650	32.225	**15.629**
	Adjective 1	-7.228	21.095	-0.343
	Match	2.560	18.568	0.138
	Trial sequence	-3.256	1.324	**-2.459**
	Adjective 1 * Match	24.346	41.851	0.582

Region 4 (random slope for interaction not included)	Intercept	532.4127	31.4720	**16.917**
	Adjective 2	7.2370	23.6520	0.306
	Match	0.7125	21.3042	0.033
	Trial sequence	-6.5523	1.2852	**-5.098**
	Adjective 2 * Match	17.2835	35.3186	0.489
Region 5	Intercept	756.286	42.676	**17.722**
	Adjective 2	178.182	60.800	**2.931**
	Match	21.956	22.599	0.972
	Trial sequence	-7.491	1.541	**-4.862**
	Log Frequency	-48.622	18.628	**-2.610**
	Length	-39.025	30.452	-1.282
	Adjective 2 * Match	129.692	49.255	**2.633**
Region 5, Simple effects				
Degree items				
	Intercept	840.846	50.125	**16.775**
	Match	78.747	35.045	**2.247**
	Trial sequence	-6.908	2.382	**-2.900**
Cardinality items				
	Intercept	670.338	37.565	**17.845**
	Match	-45.220	28.369	-1.594
	Trial sequence	-8.432	1.915	**-4.402**
Region 6	Intercept	796.672	38.066	**20.929**
	Adjective 2	-20.796	24.164	-0.861
	Match	9.256	23.517	0.394
	Trial sequence	-8.085	1.544	**-5.238**
	Adjective 2 * Match	-10.125	45.688	-0.222

Regressions Out		Estimate	Std. Error	*z*- value	*p*-value
Region 2	Intercept	-1.373911	0.200453	-6.854	**7.18e-12**
	Adjective 1	0.522995	0.213939	2.445	**0.0145**
	Match	0.312229	0.218805	1.427	0.1536
	Trial sequence	0.002585	0.013628	0.190	0.8496
	Adjective 1 * Match	-0.005188	0.392773	-0.013	0.9895
Region 2 (length and log frequency included)	Intercept	-1.368903	0.202174	-6.771	**1.28e-11**
	Adjective 1	1.233136	0.398793	3.092	**0.00199**
	Match	0.320696	0.205845	1.558	0.11925
	Trial sequence	0.002289	0.013642	0.168	0.86674
	Log Frequency	0.030675	0.110799	0.277	0.78189
	Length	-0.247276	0.141079	-1.753	0.07964
	Adjective 1 * Match	-0.060746	0.382493	-0.159	0.87381
Region 3	Intercept	-3.35838	0.24826	-13.528	< 2e-16
	Adjective 1	0.35208	0.52100	0.676	0.499185
	Match	1.65242	0.45275	3.650	**0.000263**
	Trial sequence	-0.01868	0.02518	-0.742	0.458155
	Adjective 1 * Match	-0.65702	1.03622	-0.634	0.526050

Region 4 (random slope for interaction not included)	Intercept	-2.73041	0.25553	-10.685	<2e-16
	Adjective 1	0.46602	0.29973	1.555	0.120
	Match	-0.18381	0.30495	-0.603	0.547
	Trial sequence	-0.01210	0.01862	-0.650	0.516
	Adjective 1 * Match	-0.72555	0.52875	-1.372	0.170
Region 5 (random slope for interaction not included)	Intercept	-3.70081	0.30102	-12.294	<2e-16
	Adjective 2	0.58683	0.66517	0.882	0.378
	Match	0.66420	0.50435	1.317	0.188
	Trial sequence	0.02458	0.02682	0.916	0.359
	Log Frequency	0.18425	0.21530	0.856	0.392
	Length	0.03491	0.26955	0.129	0.897
	Adjective 2 * Match	1.27369	0.77451	1.645	0.100
Region 6	Intercept	-2.15485	0.26762	-8.052	**8.16e-16**
	Adjective 2	0.01994	0.25817	0.077	0.938425
	Match	0.30233	0.23466	1.288	0.197624
	Trial sequence	-0.05571	0.01674	-3.329	**0.000873**
	Adjective 2 * Match	0.76311	0.59433	1.284	0.199145

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